JULY • 1956

PETROLEUM REFINER

REFINING | PETROCHEMICALS | NATURAL GASOLINE

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• *Special Report* . . . Higher Octanes or Not? . . . Page 137
• All About Octane Scales . . . Page 162
• More Profits from Capital . . . Page 199

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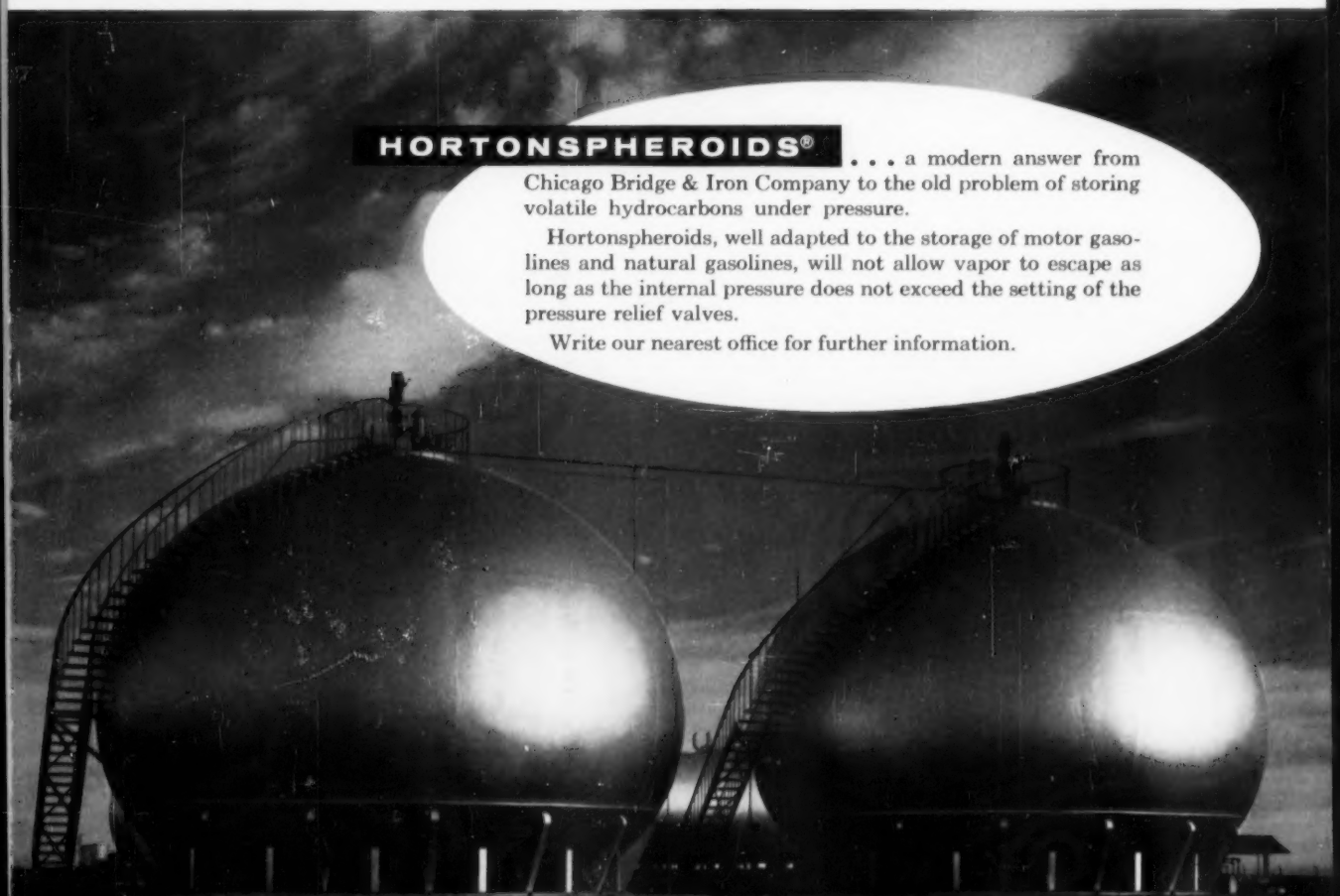

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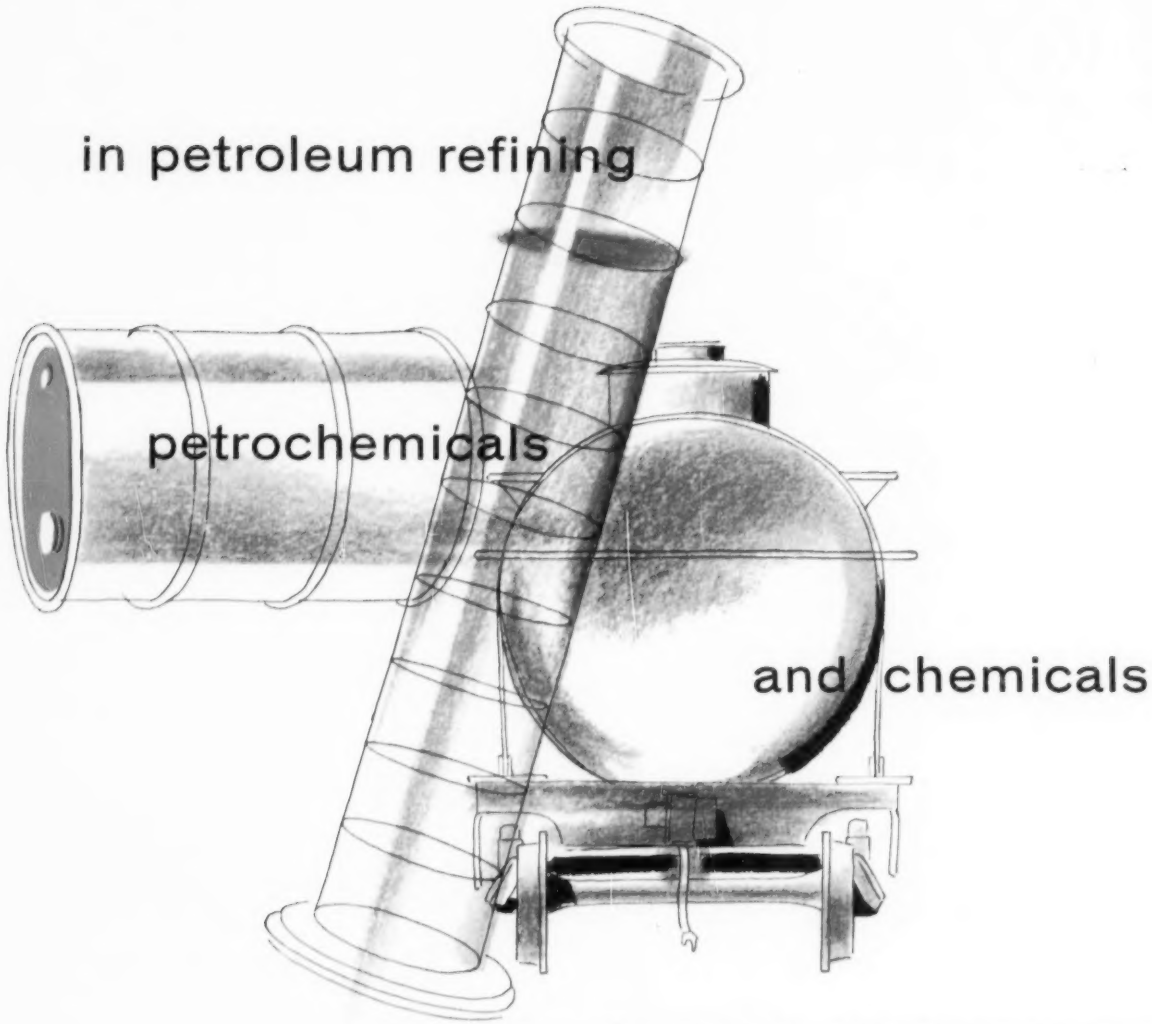

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PETROLEUM REFINER
REFINING | PETROCHEMICALS | NATURAL GASOLINE

A Quick Look at This Issue

These handy digests permit checking ✓ those articles you want to read first.

HIGHER OCTANES OR NOT?

☐ **Turbo Autos for the Future** . . . Introduction of the gas turbine as an automotive engine will make motor fuel octanes obsolete. To see what the chances are that this will happen, review the present status of the gas turbine starting on **Page 138.**

☐ **Fuel Injection Changes Emphasis** . . . This development introduces a new element of control into the burning process of an internal combustion engine. It may help make the automotive engine completely insensitive to octanes while it is improving thermal efficiency. See how this will change the fuel requirements of an auto by turning to **Page 145.**

☐ **Isomerize C_5 and C_6 with Penex** . . . Those low octane components in the pentane and hexane fractions of motor fuel can now be up-graded. One of the new processes which can do this is called Penex. For data on what this process can do, turn to **Page 148.**

☐ **Automation Today (Part 4)** . . . System instability is a limiting factor in the application of automatic control. Graphical methods may be used to predict and correct for process instability. A discussion of some of these methods starts on **Page 149.**

☐ **When Will Shale Oil Compete with Crude?** . . . The long-entertained hopes of profitably producing oil from shale may be near realization. Promising methods have been developed by the U. S. Bureau of Mines. Engineers believe that it may soon be possible to produce oil from shale at practically the same cost that crude oil is being produced in many U. S. fields. A competitive cost for shale oil would require volume throughput and a continuous retorting operation. See **Page 153.**

→ Now Turn the Page →

A Quick Look at This Issue . . .

☐ **Retort Oil Shale for Chemicals** . . . The severity of retorting greatly influences the amount and type of chemicals available from oil shale. This material offers an attractive and unexploited source of petrochemicals. Manufacturing liquid fuels and recovering by-product chemicals can make retorting shale economical. Clip this article and review your shale reserves . . . Turn to **Page 155.**

☐ **Union Oil of California Bets Heavily on Shale Oil** . . . Shale oil is destined to occupy a more important part in oil industry's thinking—and expenditures—if recent developments at Union Oil Company of California are any measure. Early in 1955 the company earmarked $5 million for oil shale research over 2½-year period. Now they say: "We believe we have reached the point where the higher and increasing costs of discovery of new sources of crude oil are making more attractive the development of a shale oil industry." Turn to **Page 161.**

☐ **What's All the Controversy About Antiknock Scales Over 100?** . . . One side wants to define octane numbers above 100 in units of performance numbers. The other side wishes to extend the octane scale smoothly through the 100 octane number. In these three articles you'll find both sides presented plus a history of the development of the octane scale. Turn to **Page 162.**

☐ **Fast Butane Analysis** . . . Why wait for low temperature fractionation analysis of butane-isobutane mixtures? Don't invest in elaborate infrared apparatus. Use this simple and inexpensive method for accurate and reproducible results. Introduce this into your control laboratory now, turn to **Page 175.**

☐ **Make Petrochemicals from Air and LPG** . . . The many variables and their effect on product yield in the manufacture of oxygenated petrochemicals are discussed. The results of varying oxygen ratio, pressure and temperature of the reaction are explained and analysis of the products given. Add this to your file on oxygenated petrochemicals by turning to **Page 179.**

☐ **How to Stop Corrosion in Sulfur Plants** . . . Stanolind has found ways to stop corrosion in three sulfur recovery plants that have been operating for six years. Cause was condensation of water in process streams and the solution was redesigning and insulating equipment. For a complete analysis of their experience, turn to **Page 183.**

☐ **How to Steam Trace Refinery Piping** . . . Do you "engineer" your steam tracing systems? Proper sizing of traps and lines can prevent costly shutdowns. The key factor is condensation of steam in the tracer line to transfer heat to the process line. For details on how it should be done, turn to **Page 187.**

☐ **Make High Octane Alky for Motor Fuel** . . . Here is a short report from a company that has been able to get high octane alkylate with low acid consumption. Check these data against those obtained from your own plant by turning to **Page 192.**

☐ **What Unifining Can Do for You** . . . Can you get high quality products from low grade crudes? Can you integrate Unifining into your present operating plant? These and many other questions are answered in this complete story. The author shows five separate cases of handling a sour, low gravity crude. You'll see how these data can fit your operation on **Page 193.**

☐ **How to Invest Your Capital for Profits** . . . Don't waste valuable estimating time on marginal projects. Here is a method for selecting those projects that deserve a detailed estimate. All of the elements of economic analysis are discussed. Add this to your "how-to-do-it" file . . . Turn to **Page 199.**

☐ **Two Jersey Affiliates Build to Meet Postwar Demands** . . . This month, two more Standard Oil Company (New Jersey) affiliates are covered in the series on postwar refinery construction. One is The Carter Oil Company, with its refinery at Billings, Mont. The other is Jersey's German affiliate, Esso, A. G., with a refinery at Hamburg and plans to build at Cologne. For the postwar story of these companies . . . Turn to **Page 134.**

☐ **Accident Control Through Supervision** . . . Last year's increase in accident ratio over 1954 points up the need for a more aggressive safety effort in refineries. Here is an excellent accident prevention program—emphasizing the vital role of foremen and supervisors—that will help reduce costly injuries in any operation. Turn to **Page 254.**

☐ **Management's "Forgotten Men"** . . . Here is an outstanding analysis of modern industry's executive manpower problem. For a revealing study of the growing trend toward more management development programs—sources of executive material—and many excellent ways to develop executive talent . . . Turn to **Page 262.**

This month's Construction Boxscore begins on Page 235

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PETROLEUM REFINER and The REFINERY CATALOG for the refining natural gasoline-petrochemical industry

WORLD OIL (formerly The Oil Weekly) and The COMPOSITE CATALOG for the drilling-producing industry

PIPE LINE INDUSTRY and The PIPE LINE COMPOSITE CATALOG (first edition to be issued in July, 1957) for the oil and gas pipe line industry.

Petroleum Refiner is indexed by Industrial Arts Index, Chemical Abstracts and by Engineering Index, Inc. Microfilm copies available through University Microfilms, An Arbor, Michigan.

Short Short-Cuts

WITH EVERYONE putting a premium on time these days, PETROLEUM REFINER has prepared a Special Report for August which is really a time saver. "Cost and Economics in the Process Industries" is the theme.

These time savers are really short-cuts, actually are *big* time savers!

The Special Report will be divided into three parts: (1) Economics in a Hurry; (2) Estimates in a Hurry and (3) Rapid Evaluation articles. This will present a group of useful articles for those engaged in estimate preparation, process evaluation and equipment selection.

The equipment selected for specific cost studies will be of genuine interest throughout the process industries. Actually, in most cases, there is little difference between equipment used in refineries, petrochemical plants and natural gasoline plants. Only the process fluid being handled is different. So our selection of a cross-section of equipment for study will find applications all through the process industries.

Costs! Costs! Costs!

AND SPEAKING of costs, we know from your many letters and from personal discussions that you read with the highest interest any good article on costs or economics.

Do you know that virtually each issue of the PETROLEUM REFINER contains at least one (and quite often several) such articles involving the dollar sign? In fact, every issue of PR this year brought new cost information to you on some phase of equipment, methods, processes and design for the refining, petrochemical or natural gasoline industry.

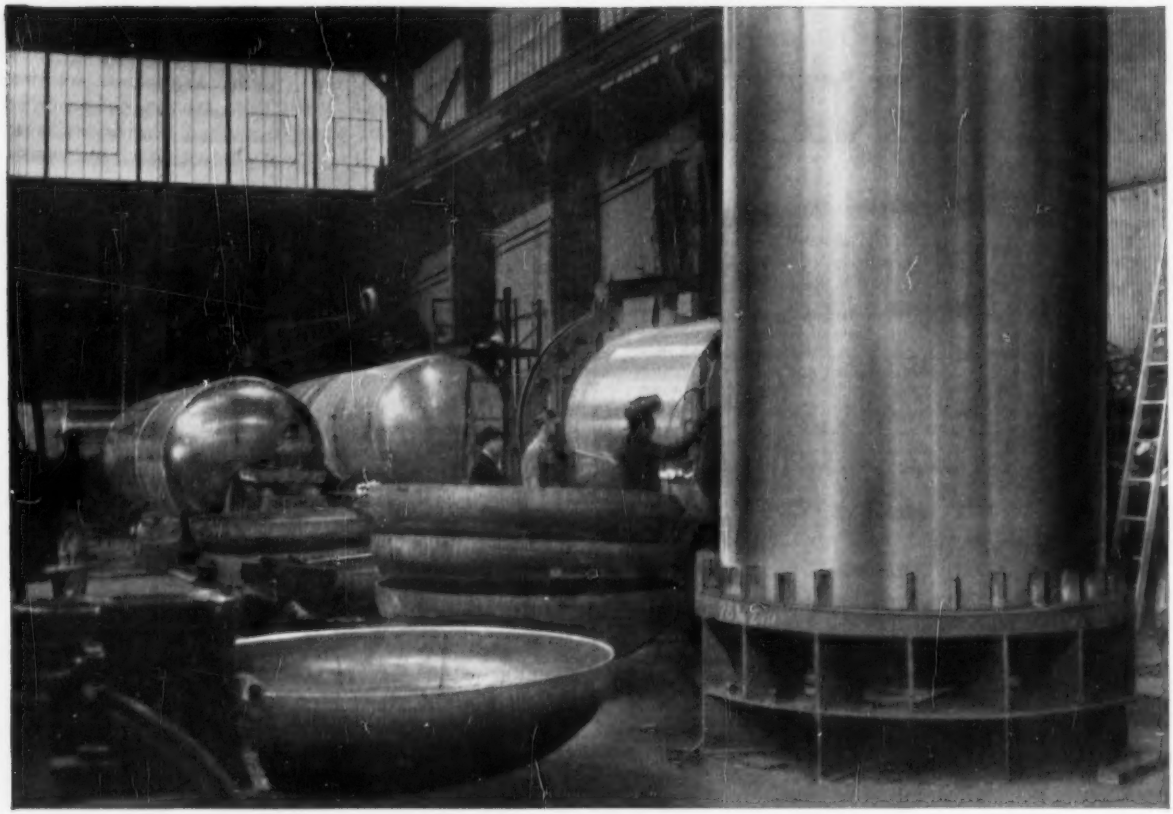
Since you indicate strongly that you've enjoyed our coverage of costs and economics we will continue to bring them to you. *Each month* the PETROLEUM REFINER will carry at least one good cost article for your reading pleasure and job profit.

Plea on a Birthday

THIS MONTH marks the tenth year the Construction Boxscore has appeared as an exclusive feature in the PETROLEUM REFINER. During that time, it has become a valuable aid to subscribers and firms wanting to keep up with new construction in the Refining-Natural Gasoline-Petrochemical industry.

But there is no royal road to success. We are dependent upon friends in the industry to help us maintain a continuing check on the industry's world-wide building program. Replies to our inquiries, together with volunteered information from our readers, are essential to the successful compilation of this quarterly feature. (It started out on a monthly basis.)

If you know of any projects not listed, or have any additions or corrections to the data aleady appearing, send the information to the Editor, PETROLEUM REFINER, Box 2608, Houston 1, Texas. Your cooperation is always appreciated.



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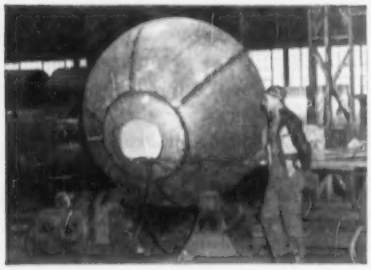
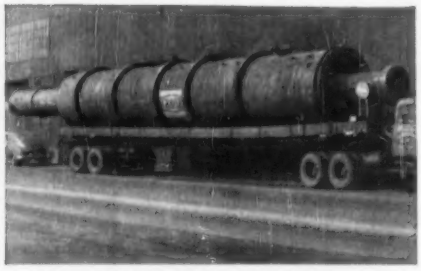


Solid stainless sphere for gas



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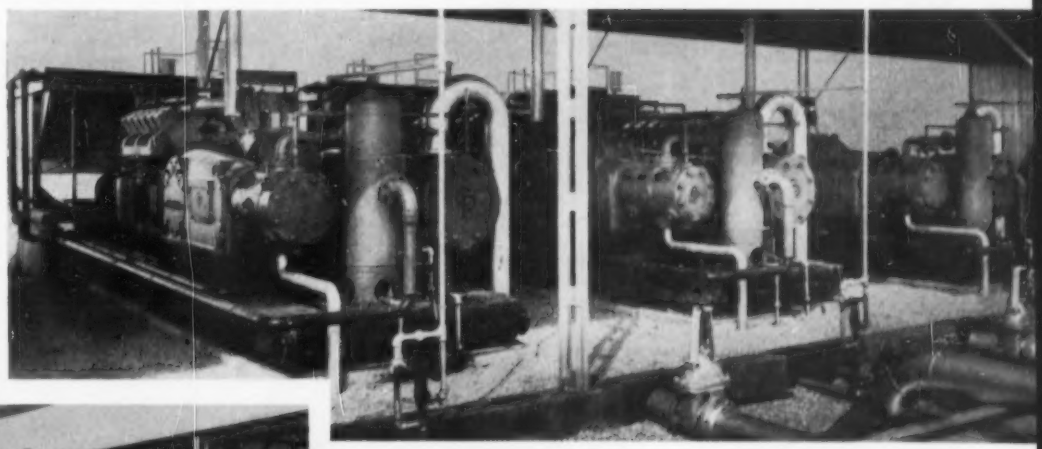
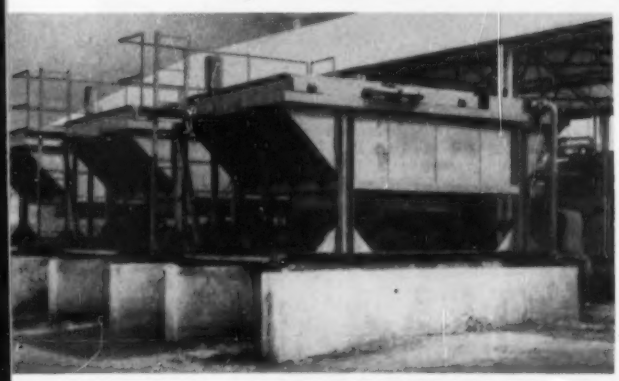
Units of this type are available in 125, 175, 200, 250 and 300-hp sizes. On all but the two larger sizes, up-draft radiators are mounted above the compressor gear box and supported directly from the skid base.

This bank of three direct-connected units are tied into a common header system, permitting flexibility of operation.



Heavy-duty, horizontal, up-draft radiators have divided cores for separately cooling engine and compressor. Circulating pumps and cooling fans are driven from the engine crankshaft by means of a torque tube and fluid coupling.



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DM	4-6% Cr.-Mo.	18-8 Stainless	35-15**
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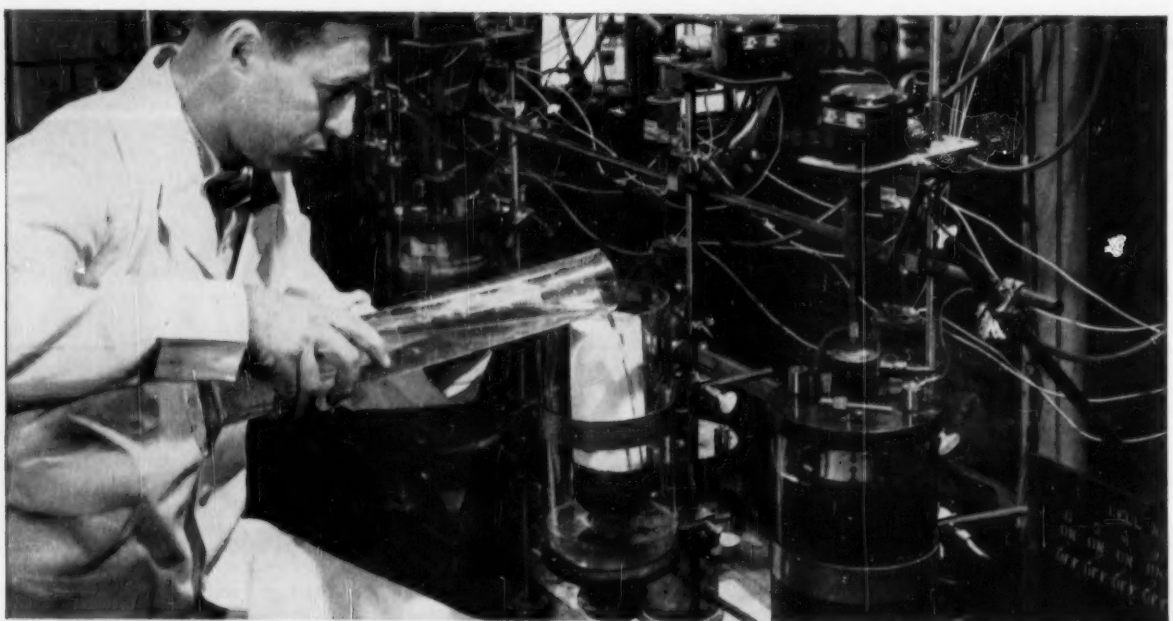
Let the Timken Company's metallurgists help solve your tube problems. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".



Electrolytic equipment used in Timken Company laboratories to extract non-metallic inclusions from steels in research on steel cleanliness

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

UNITED STATES STEEL

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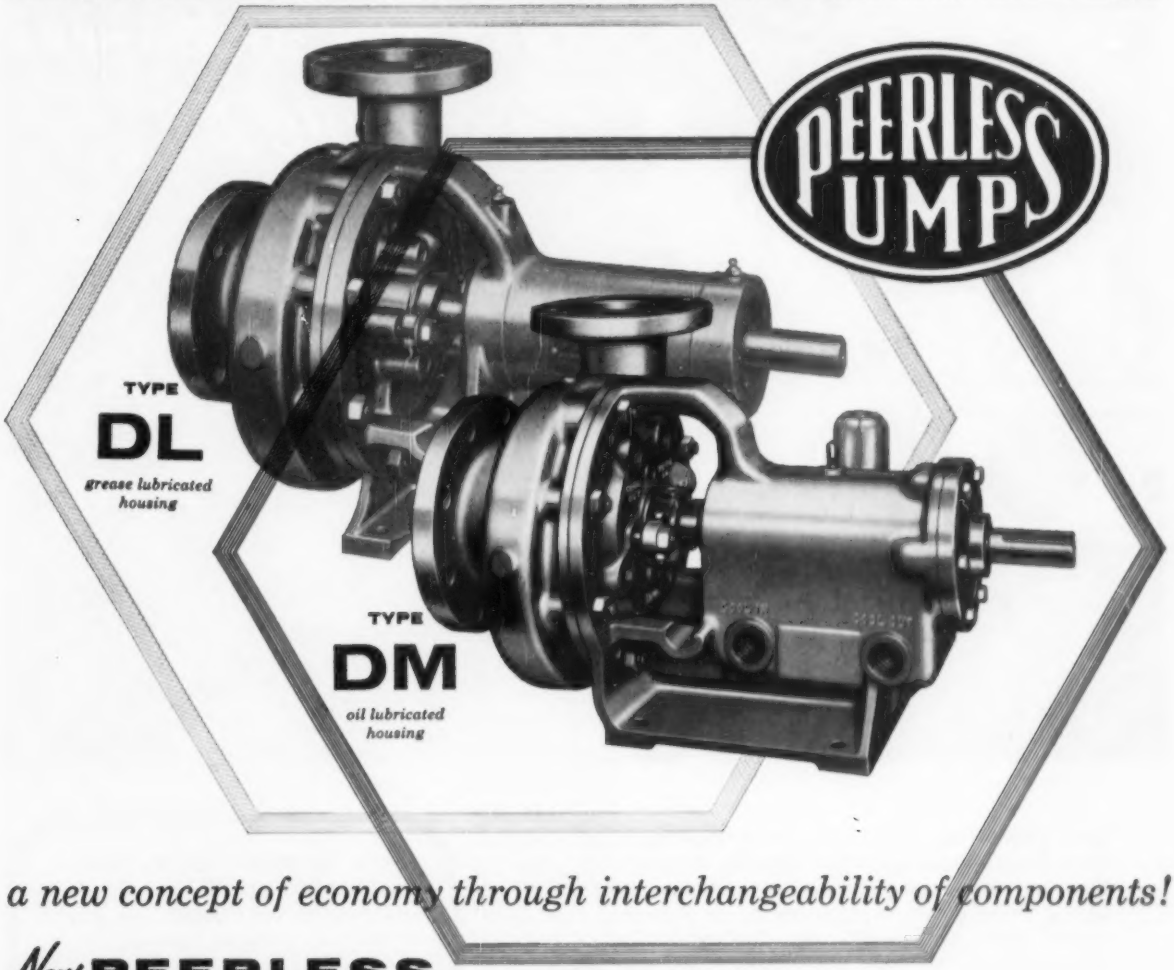

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ACCESSIBILITY—Through ease of assembly and disassembly if and when required. **DURABILITY**—Through use of any machinable metal as materials of construction. **SERVICEABILITY**—Through designs that feature maximum ease of maintenance. **INTERCHANGEABILITY**—Through a choice of semi-open or enclosed impellers, oil or grease lubrication, air-or water-cooled back plates and bearing housings. **RELIABILITY**—Through the high performance standards set for these pumps, proving more than ever before, that Peerless Builds Dependable Pumps. **AVAILABILITY**—Through shipment from stock of both complete pumps and pump components.

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Peerless Type DL and Type DM process pumps are available in 1″, 2″, 2½″ and 3″ sizes on an 8½″ frame and in 1″, 2″, 2½″, 3″ and 4″ sizes on a 10½″ frame. **CAPACITIES:** up to 800 gpm. **HEAD RANGE:** up to 430 feet. **DRIVES:** motor or steam turbine. **TEMPERATURE RANGE:** grease lubricated housing up to 250°F.; oil lubricated housing up to 450°F. **WORKING PRESSURES:** up to 400 psig.

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Good coffee—the kind that attracts knowing truckers to their favorite roadside stops—depends on careful preparation, *and* maintenance at *just the right temperature until serving*. That's why manufacturers of restaurant coffee makers have consistently used Rochester Bimetal Dial Thermometers for years. They know RMC thermometers assure customer satisfaction by giving long, trouble-free, dependable service.

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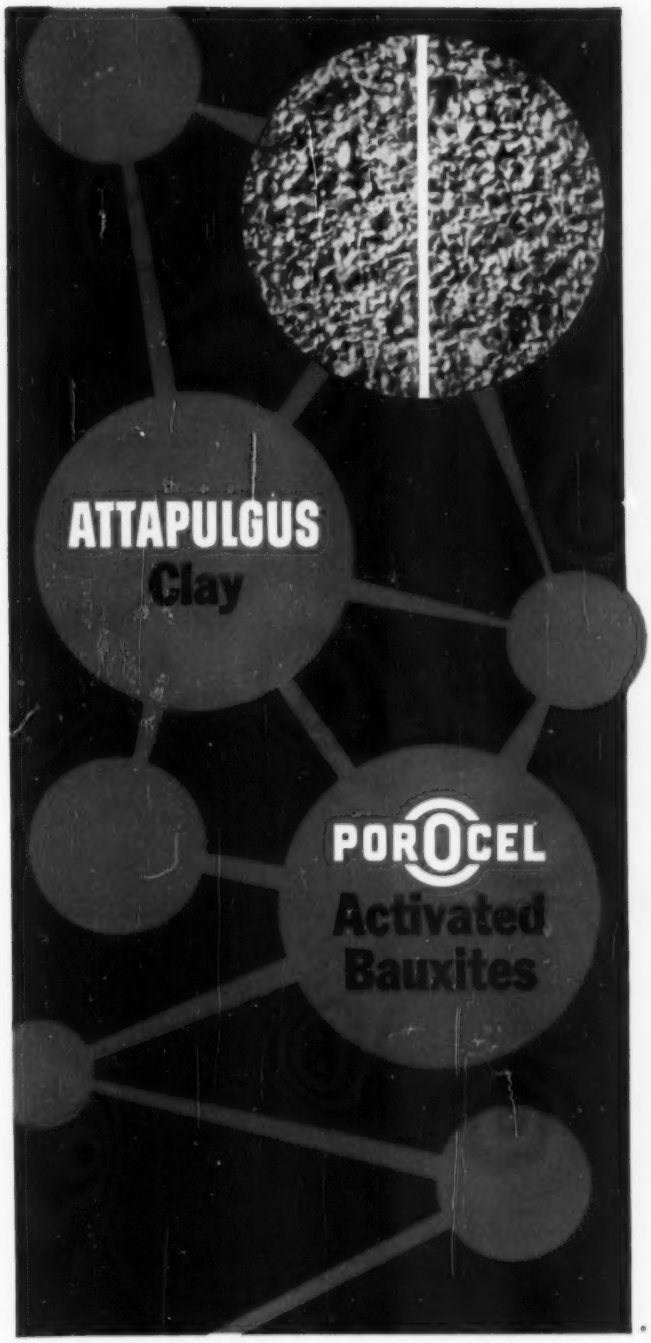


Here's the way to tackle a sorptive-mineral job

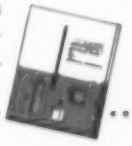
Away up in number two slot in a list of nearly 2,000 different chemicals used in petroleum refining operations is *sorptive minerals*. And the adsorbents recognized as standards in the industry are Minerals & Chemicals products—Attapulgus Clay . . . Porocel Activated Bauxites. That means there's a *headquarters* to turn to!

Want To Purify By Adsorption? **There's an M&C adsorbent to fit your process scheme for removing odors, colors, taste, moisture, acids, sulfur compounds, fluorides and unsaturates from process liquids or gases.**

Catalyst Carrier? **M&C sorptive minerals are of highest importance in a wide variety of hydrocarbon conversion and sweetening processes.**

What Do You Want To Dry? **M&C offers a complete line of reliable desiccants for drying air, hydrogen, CO_2, hydrocarbon liquids and gases.**

HERE'S THE NEWEST APPLICATION *of sorptive minerals in the petroleum field. Mail the coupon for your free copy of "Preparation of Petroleum Feeds for Platinum Catalysts"— and for other assistance if desired.*



ATTAPULGUS *and* **POROCEL PRODUCTS** *from*

MINERALS & CHEMICALS CORPORATION OF AMERICA
14 ESSEX TURNPIKE, MENLO PARK, NEW JERSEY

ALWAYS A BETTER WAY . . .

MINERALS & CHEMICALS CORPORATION OF AMERICA
14 Essex Turnpike, Menlo Park, N. J.

☐ Please send me "Preparation of Petroleum Feeds For Platinum Catalysts."

☐ Please provide technical help (and samples) on the following proposed applications: _____

_____

name _____ title _____

company _____

address _____

city _____ zone _____ state _____

For more data on advertised products, use Readers' Service Cards, last page.

. . . there's enough difference to make ALL the difference

Every single finished Scovill Heat Exchanger Tube is subjected to a 1,000-lb. hydrostatic pressure test and an 80-lb. air pressure test under the eyes of experienced inspectors. Very seldom does a tube fail at this point; yet this and other final inspections for tube perfection are always rigidly maintained.

Before Scovill Heat Exchanger Tubes reach these final inspection benches, specialized production methods and controls have already assured their inherent uniformity in alloy composition . . . with soundness in metal structure . . . and dense, smooth surfaces, free from defects. Scovill safeguards assure delivery to customers of tubes in top physical condition . . . an essential to dependable heat exchanger service.

Scovill Technical Service stands ready to help you select the correct tube alloys for your applications, with recommendations based on most comprehensive experience records.

Scovill Manufacturing Company, Mill Products Division,
99 Mill Street, Waterbury 20, Connecticut. Phone: Plaza 4-1171.

SCOVILL HEAT EXCHANGER TUBE

Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Muntz Metal • Naval Brass • Red Brass, 85% • Deoxidized Copper
Arsenical Copper • Copper Nickel, 10% & 20% • Cupro Nickel, 30% • Aluminum Brass • Aluminum Bronze, 5% • Duplex Tube

119C56

DESIGN
ENGINEERING
CONSTRUCTION

TRECo

A DIVISION OF VITRO CORPORATION OF AMERICA

The REFINERY ENGINEERING Company

NEW YORK TULSA TORONTO

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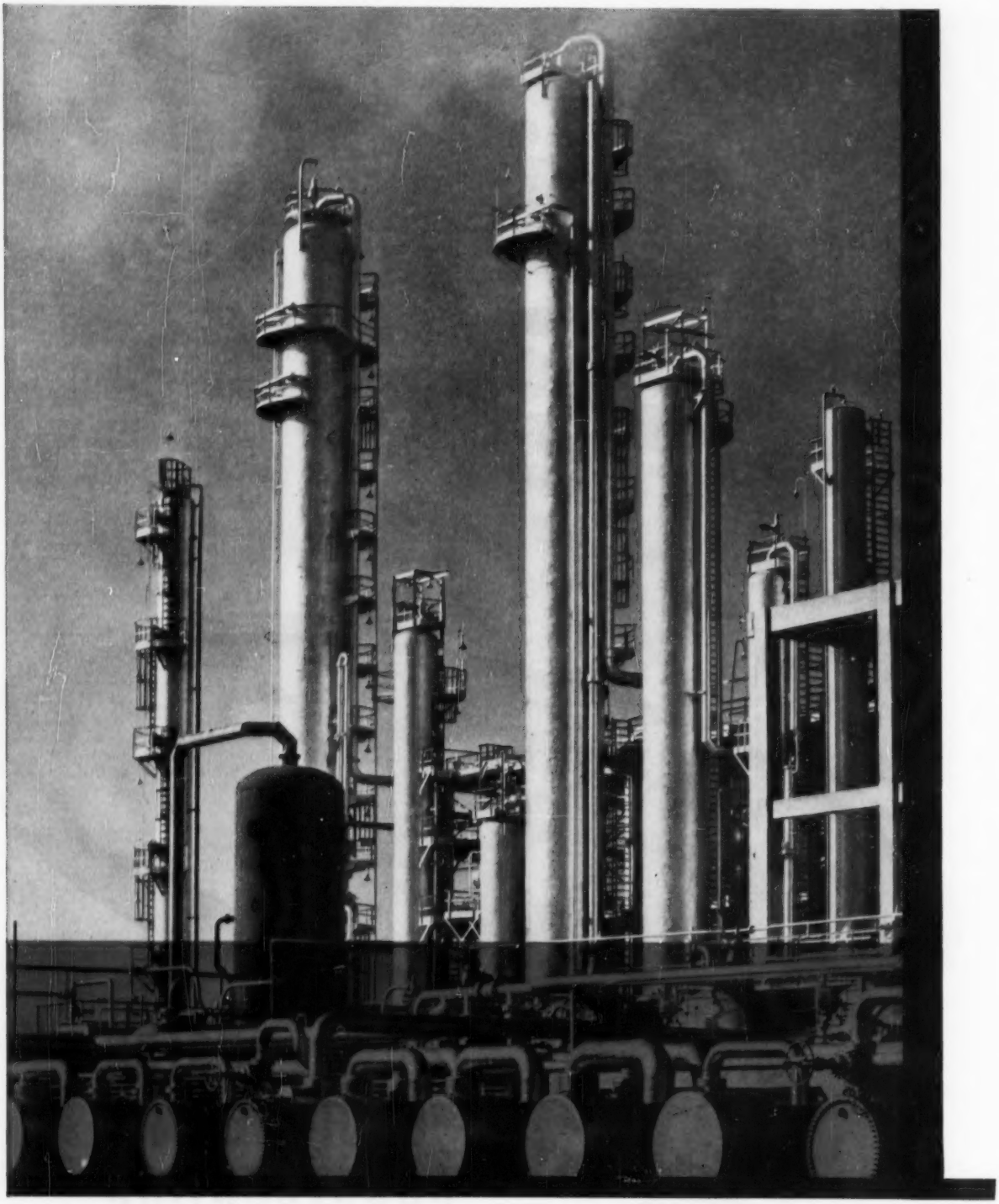
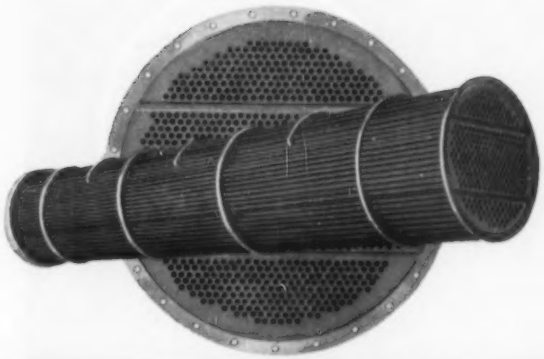


FIRST FOR LASTING QUALITY—FROM MINE TO MARKET!



For dependable "on-stream" performance . . .
retube your exchangers with

PHELPS DODGE HEAT EXCHANGER TUBES!

Wide selection of copper-base alloys for every type of application—including bi-metal combinations.

Complete warehouse stocks maintained at Houston, Texas; Tulsa, Okla.; Los Angeles, Cal.; Chicago, Ill.; and Bayway, N. J.

Expert assistance in solving your tube corrosion problems.

Specify Phelps Dodge . . . One of the largest suppliers of tubes to manufacturers of heat exchangers!

PHELPS DODGE COPPER PRODUCTS CORPORATION

SALES OFFICES: Atlanta, Birmingham, Ala., Boston, Buffalo, Charlotte, Chicago, Cincinnati, Cleveland, Dallas, Detroit, Fort Wayne, Greensboro, N. C., Houston, Jacksonville, Kansas City, Mo., Los Angeles, Milwaukee, Minneapolis, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Richmond, Rochester, N. Y., San Francisco, St. Louis, Seattle, Washington, D. C.

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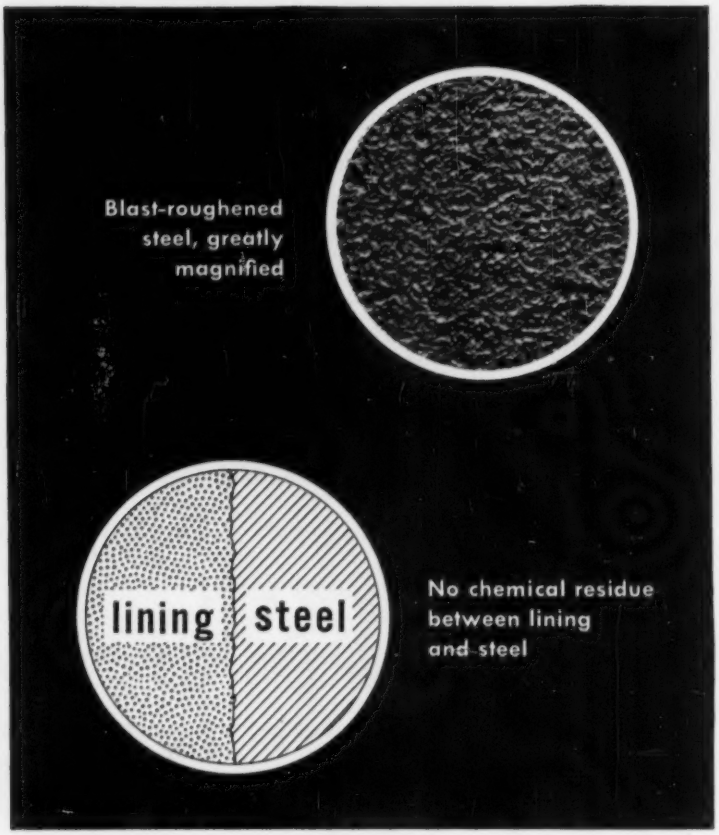
Rough treatment proves



Rheem Shot-Blasted drums can take it

Shipment never *helped* a lined steel drum or a product. Everything works against them. High-speed clatter, jarring blows, quick shifts from hot to cold—an obstacle course all the way.

But punishment is nothing new to Rheem drums. They've been through it all before in Rheem laboratories. Our engineers learn from special test trips how to team linings with products, and how to best *apply* the linings. They learned long ago that *any* good lining starts with the steel.

Rheem blasts its steel drums under a hailstorm of high carbon steel shot. This physically scours and roughens the metal—cleans away scale, too—and leaves a sawtoothed, naked surface for linings to grip. In other words, they're *integrated* directly to the steel.

And Rheem learns more from planned abuse, like how to cure linings on drum bodies and on their tops and bottoms in separate ovens for the individual treatment their different shapes require.

Rheem will go on learning ways to build better containers, better linings, and better product protection. Keeping ahead of trouble is just part of never ending research that's made Rheem the world's leading producer of steel shipping containers.

E. D. C. B. A.

Have a hard-to-hold product? Chances are our lab has a lining just right for you. They have A to Z experience in solving lining problems. Write today.

RHEEM MANUFACTURING COMPANY

3001 Jefferson Hwy., P.O. Box 4027, Carrollton Station, New Orleans 18, La.
1025 Lockwood Drive, Houston 20, Texas

NAME_____

COMPANY_____

POSITION_____

STREET_____

CITY_____ ZONE____ STATE_____

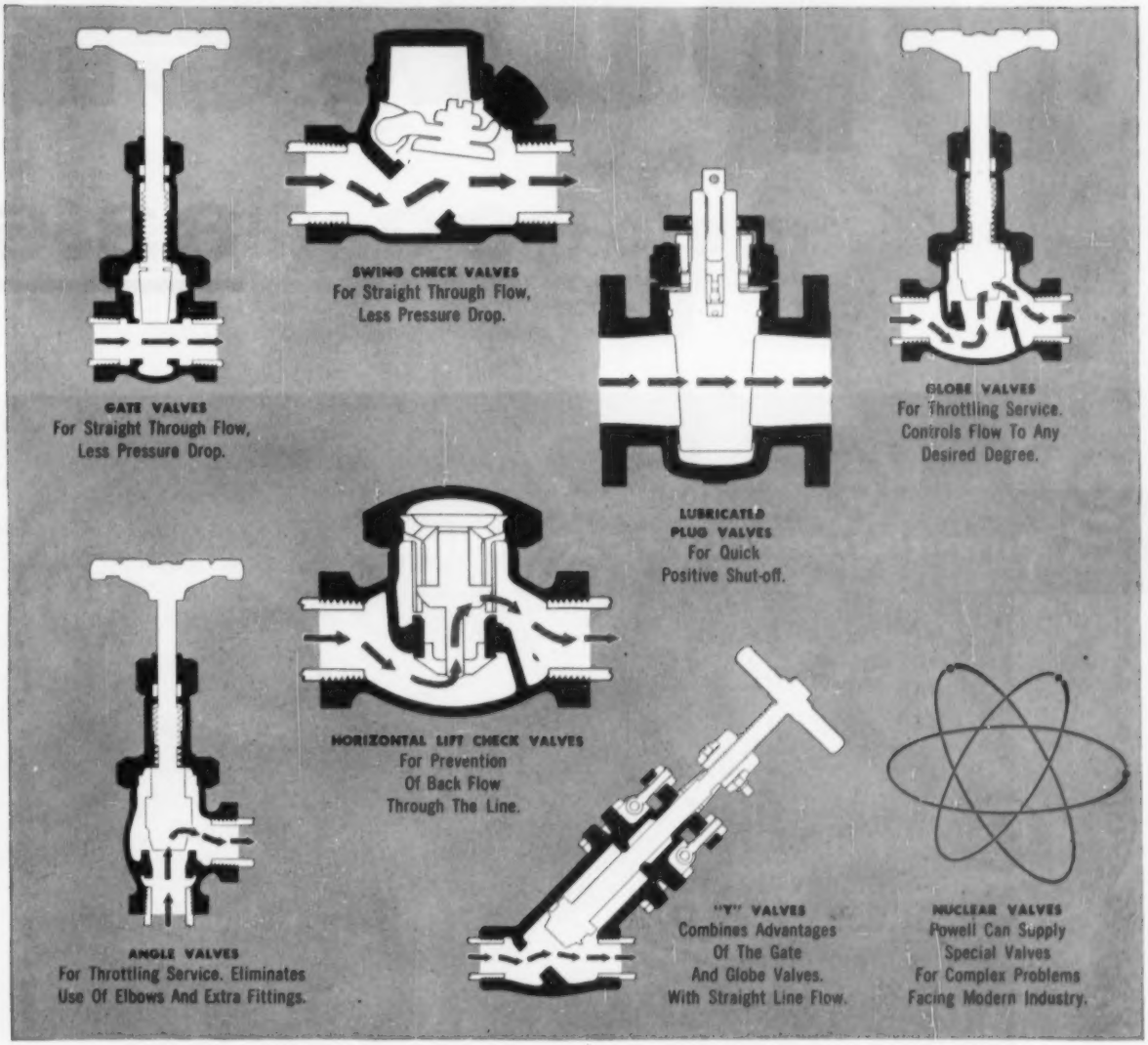
PRODUCT_____

PR-7

YOU CAN RELY ON Rheem **MANUFACTURING COMPANY**

RICHMOND AND SOUTH GATE, CALIF.; HOUSTON, CHICAGO, NEW YORK, NEW ORLEANS; LINDEN, N. J. AND SPARROWS POINT, MD.

POWELL
for all valve needs



for every flow control problem there is a right Valve

Powell can supply this right valve—*made right* of the right material*. Every part of every valve must pass rigid inspection. And as a final step in manufacture, every Powell Valve has *Performance Verified* through an *actual line test.*

As an aid in selecting the right valve, the basic valve designs are illustrated here. For complete information on the wide range of sizes and materials available in each type of the basic valves illustrated above, consult your Powell Valve distributor. If none is located near you—or if you have a special flow control problem—write direct to The Wm. Powell Company, Cincinnati 22, Ohio.

PERFORMANCE
PV
VERIFIED

The Wm. Powell Company, Cincinnati 22, Ohio . . . 110th YEAR

POWELL VALVES

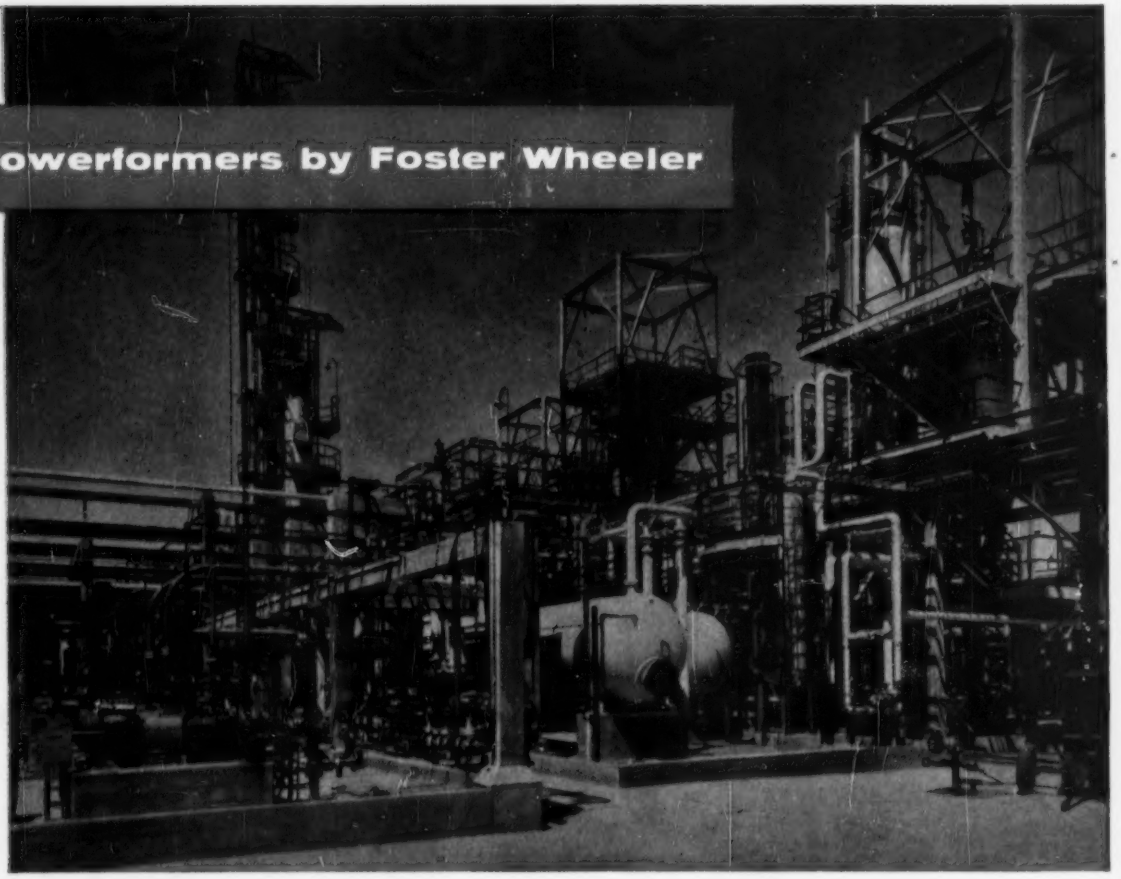
*BRONZE, IRON, STEEL AND CORROSION RESISTANT VALVES

For more data on advertised products, use Readers' Service Cards, last page.

power

83.6

3 Powerformers by Foster Wheeler



This Powerforming unit, designed and constructed by Foster Wheeler for Esso's Baltimore refinery, charges approximately 3,000 barrels per day of heavy virgin naphtha which has been desulfurized in a Hydrofining unit whose operation is integrated with that of the Powerformer.

FOSTER

NEW YORK • LONDON

For more data on advertised products, use Readers' Service Cards, last page.

forming

percent, 98* clear

*Research Octane of Debutanized Reformate

- **New, more active platinum catalyst**
- **Special regenerative technique maintains optimum catalyst activity**
- **Lower pressure operation – 200 to 300 psig**
- **Higher yields of high octane reformate**

This combination provides the refiner with a most effective means for the catalytic reforming of low-octane naphthas into high-octane motor fuel components.

Powerforming, developed by Esso Research and Engineering, has already proved its outstanding performance on three units which are now in successful operation. Fourteen more are under construction or in the design and planning stage.

The first Powerforming unit, shown at the left, in operation since May 1955 was designed and constructed by Foster Wheeler for Esso's Baltimore refinery. FW is currently providing mechanical design and construction for two more Powerforming units – a 20,000 barrel per day unit at the Bayway refinery and a 7,000 barrel per day unit at Imperial's Halifax refinery where Foster Wheeler is also building Crude Distillation, Fluid Catalytic Cracking, Polymerization and Treating units. For further information write to *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

WHEELER

PARIS • ST. CATHARINES, ONT.

For more data on advertised products, use Readers' Service Cards, last page.

Bingham STUFFINGBOXLESS PUMPS

HANDLE AT HIGH

FIREPROOF AND EXPLOSION-PROOF! Leakage of vapor or liquid to atmosphere or leakage from outside into pump is *impossible*. Not only is plant and personnel protected but loss of valuable pumpage is prevented. Type KC High-Pressure Single-Stage Stuffingboxless Pump illustrated.

NO STUFFING BOX! NO PACKING!

Bingham Stuffingboxless Pumps are successfully handling liquids having high vapor pressure, requiring high suction pressure and, frequently, abnormally low pumping temperature (—300° F). Standard models handle suction pressures up to 2,000 psi (higher pressures available). Pumping temperatures to 850° F and higher also can be handled. These conditions present no difficulty for Bingham Stuffingboxless Pumps, but they are difficult and sometimes impossible to meet with conventional pumps due to limitations imposed by the stuffing box.

Because there is *no stuffing box,* Bingham Stuffingboxless Pumps eliminate all the disadvantages of conventional pumps operating with stuffing boxes equipped with packing or mechanical seals.

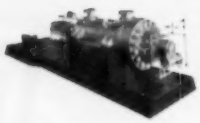
Bingham Stuffingboxless Pumps are in service today all over the world, with distinguished records in reliability, continuity of service, and low maintenance. Write to your nearest Bingham office for Bulletin 107 or for additional information.

***And other volatile liquids.**

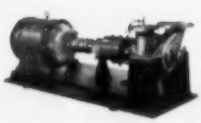
TYPICAL BINGHAM "DOUBLE VOLUTE"

The Bingham Type HPD "Double Volute" Multi-Stage Double Case "Hi-Press" pump for extremely high pressure service.

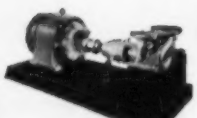
Bingham Type VS Single-Stage Wet-Pit Pump for high capacity, medium head service.



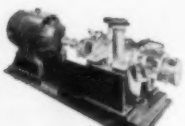
Bingham Type CP "Double Volute" Multi-Stage, Double-Case pump for hot or cold service.



A Bingham Type CKA "Double Volute" Single-Stage Koke-Krusher for coke-laden pumpage.



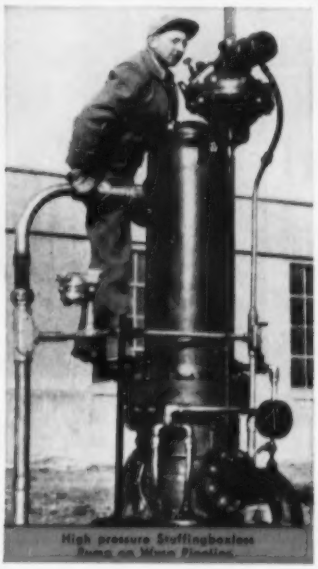
Bingham Type CAD "Double Volute" Single-Stage Process Pump.



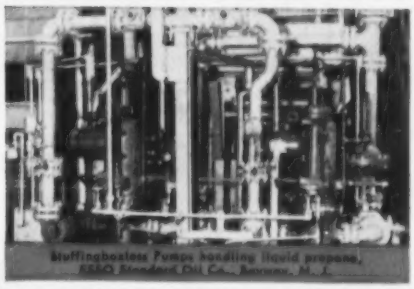
Bingham Type CM vertically split-case two-stage pump for hot service.

LIGHT HYDROCARBONS* SUCTION PRESSURES

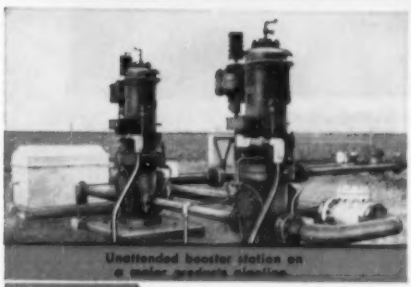
High Pressure Stuffingboxless Pumps, Stanolind Oil & Gas Co., Ponca, Okla.



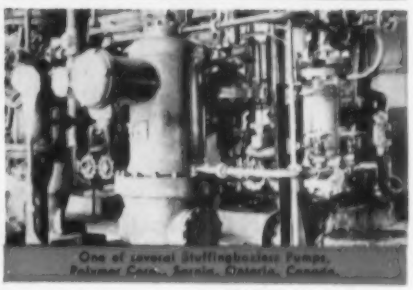
High pressure Stuffingboxless Pump on Wyco Pipeline



Stuffingboxless Pumps handling liquid propane, ESSO Standard Oil Co., Bayonne, N. J.



Unattended booster station on a major products pipeline



One of several Stuffingboxless Pumps, Polymer Corp., Sarnia, Ontario, Canada

Partial List of Refineries Using Bingham Stuffingboxless Pumps

British American Oil Co., Ltd.
Carbide & Carbon Chemical Co.
Canadian Investors, Ltd.
Cities Service Company
Creole Pipe Line Company
E. I. duPont de Nemours & Co.
ESSO Standard Oil Co.
Great Lakes Pipe Line Co.
Gulf Oil Corp.
Imperial Oil Company Ltd.
Polymer Corporation
Phillips Petroleum Co.
Stanolind Oil & Gas Co.
Sinclair Oil Company
Sohio Petroleum Co.
Standard Oil Company of Indiana
Tennessee Gas & Transmission Co.
Tide Water Associated Oil Co.
Texas Company
Warren Petroleum Co.

Bingham SINCE 1921

DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY
General Offices: **2800 N.W. Front Avenue, Portland 10, Oregon**
Factories: **Portland, Ore. • Vancouver, B. C., Canada**

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NEW ORLEANS, LA.
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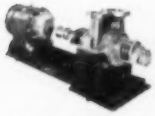
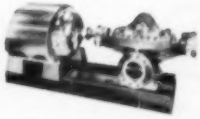
ST. PAUL, MINN.
TULSA, OKLA.
TORONTO, ONT., CAN.
VANCOUVER, B. C., CAN.

PUMPS FOR PETROCHEMICAL SERVICE



Bingham Type CD "Double Volute" Double Suction vertically-split case pump for hot service.

Bingham Type CJ "Double Volute" Two-Stage Process Pump.



Bingham Type HSB "Double Volute" Double Suction Pump for high heads.

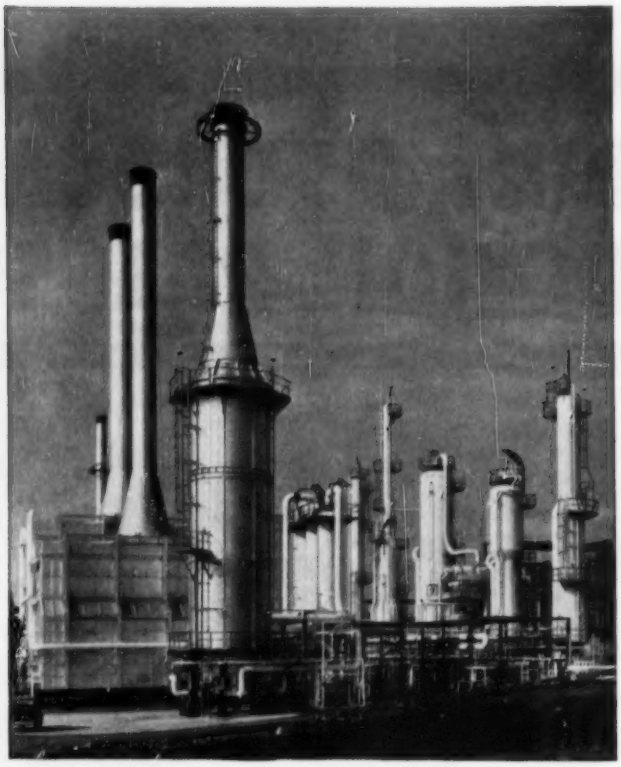
Bingham Type MSB Horizontally Split-Case Multi-Stage Pump for high pressure hot or cold service.

Bingham Type KT Stuffing-boxless Pump for high suction pressures and cold service.

Bingham Type VCP Vertical Pump for low NPSH conditions, featuring bottom dismantling.

For more data on advertised products, use Readers' Service Cards, last page.

INTERESTED IN UNIFINING* FOR DESULFURIZATION AND UPGRADING



• Unifining Unit
Union Oil Company of California refinery
Oleum, California

UNIFINING should be of particular interest to all operators of catalytic reformers which produce by-product hydrogen.

• Harshaw is the exclusive producer of the Union Oil Company of California cobalt-molybdate catalyst used in the recently announced "Unifining" desulfurization and upgrading process. This rugged, commercially proven catalyst is supplied in the form of cylindrical tablets conforming to rigid physical and chemical specifications established by Harshaw and Union Oil Company of California. Stability at high temperatures permits repeated regenerations if and when necessary.

Please contact Harshaw for further information on this catalyst.

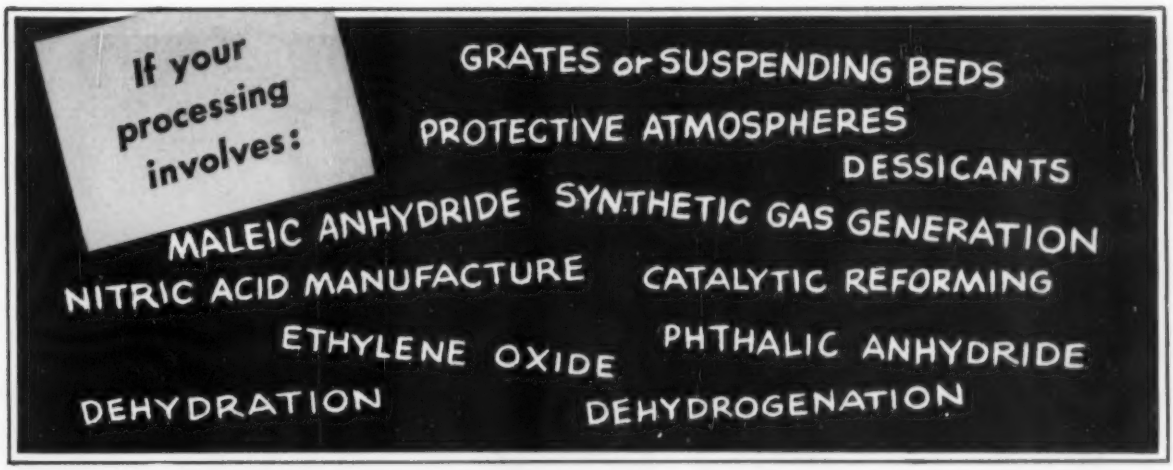
HARSHAW

THE HARSHAW CHEMICAL CO.

1945 East 97th Street, Cleveland 6, Ohio

Chicago 32, Illinois • Cincinnati 13, Ohio • Detroit 28, Michigan • Hastings-On-Hudson 6, N. Y.
Houston 11, Texas • Los Angeles 22, California • Philadelphia 48, Pennsylvania
Pittsburgh 22, Pennsylvania

* Trademark of Union Oil Company of California



You can benefit by using ALUNDUM* catalyst carriers

More and more chemical engineers are finding in Norton ALUNDUM catalyst carriers the R$_x$'s they need for faster, better, lower cost production in a wide range of processing.

These fused alumina carriers are characterized by excellent mechanical, thermal and chemical stability. They have high resistance to abrasion and erosion, and their low density is useful for packing and filling applications. Catalytically, they are crystalline in nature and are produced in two surface area types: low and intermediate. Intermediate surface area carriers are subdivided into types A, B, and C, with varying characteristics.

TYPICAL CHEMICAL ANALYSES (%'s)		
	LOW SURFACE AREA	INTERMEDIATE SURFACE AREA
Al_2O_3	89.4–76.6	77.0
SiO_2	9.3–16.8	21.2
Fe_2O_3	0.5 – 1.3	0.2
MgO	0.1 – 0.6	0.4
CaO	0.1 – 0.8	
Na_2O	0.3 – 0.4	0.5
K_2O	0.1 – 1.0	0.2
TiO_2	0.2 – 2.5	0.5

PHYSICAL PROPERTIES						
	Porosity	Water Absorption	Bulk Density	Vol. Bulk Density	Crystal Structure	Surface Area
Low Surface Area	40-50%	20-25%	1.90-2.10 gr/cc	65-80 lbs/ft³	Alpha Alumina	Less than 1m²/gram
Intermediate Surface Area Type A	50-55%	28-30%	1.65-1.70 gr/cc	58 lbs/ft³ (app)	Alpha, Gamma Alumina-chiefly Gamma	60-70m²/gram
Type B	50-55%	28-30%	1.65-1.70 gr/cc	60 lbs/ft³ (app)	Quartz, Alpha, Kappa, Delta Alumina-chiefly Quartz	20-30m²/gram
Type C	50-55%	28-30%	1.65-1.70 gr/cc	62 lbs/ft³ (app)	Alpha Alumina and Mullite	5-10m²/gram

Shapes and Sizes

Spheres: (Low surface area) 3/16"-1" diam; (Intermediate surface area) 1/4"-1/2" diam. *Pellets:* (All carriers) 1/8" x 1/8"-1/2" x 1/2". *Rings:* (All carriers) 1/8" x 1/4" x 3/8" O.D.-1" x 1 1/2" x 1 1/2" O.D.

Typical Applications

Low Surface Area Carriers: phthalic anhydride, maleic anhydride, ethylene oxide, protective atmospheres, synthetic gas generation, grates or suspending beds for active catalysts.

Intermediate Surface Area Carriers: catalytic reforming, dehydrogenation, dehydration, sulfuric acid manufacture, nitric acid manufacture, dessicants.

Get More Facts

on how Norton ALUNDUM catalyst carriers are *engineered and prescribed* to give you the most effective combination of physical, thermal, chemical and electrical properties. Learn how they can improve and economize your processing. Call in your Norton Refractories Engineer, or write, mentioning your specific requirements, to NORTON COMPANY, 466 New Bond St., Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Canada.

NORTON
REFRACTORIES
Engineered... Rx... Prescribed
Making better products... to make your products better
*Trade Mark Reg. U. S. Pat. Off. and Foreign Countries

For more data on advertised products, use Readers' Service Cards, last page.

Unibestos...the only single-layer pipe insulation that provides positive protection at the joints

Unibestos is the only single-layer pipe insulation that's built with the strong, long interlacing fibers of Amosite, the quality asbestos from South Africa. This unique construction permits single-layer Unibestos to form positive heat seals at hard-to-insulate joints and fittings...to provide more protection against heat loss than other single- or even double-layer insulations.

With Unibestos on the job, there is less shrinkage...more resistance to moisture, acid and chemical fumes...greater toughness to withstand shock and vibration. Easy to miter, easy to cut, this durable insulation goes on the most complex pipeline systems quickly and economically.

Fast, low-cost application...long-lasting, positive protection —these are the reasons why Unibestos is becoming the specified insulation for more and more of today's industrial operations. Unibestos® is available in sectional form through 44" O.D.

Joe Bestos says:

Remember when insulating those tough fittings, single-layer Unibestos locks in more heat than other single- or double-layer insulations!

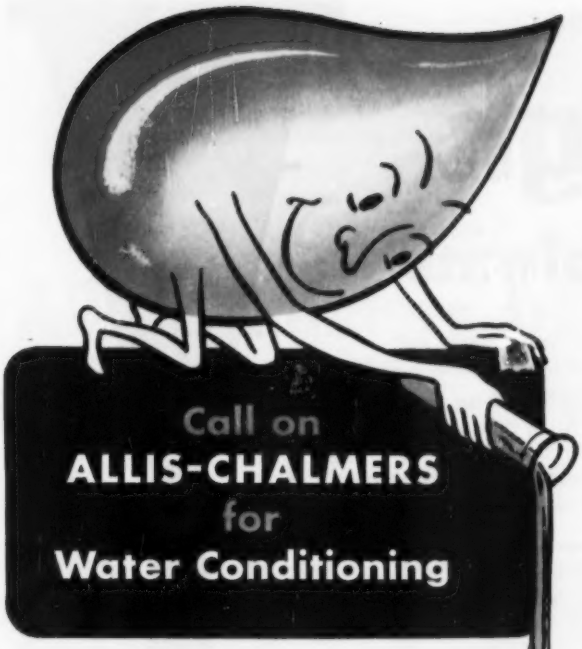
For complete information write...

UNARCO

UNION ASBESTOS & RUBBER COMPANY

1111 West Perry Street • Bloomington, Illinois

For more data on advertised products, use Readers' Service Cards, last page.



Kill Algae

NEW, easy, low-cost way

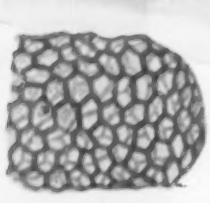
New Allis-Chalmers No. 120 Series Algaecide most toxic to all organisms in cooling towers

Many toxic materials used as algaecides are either difficult to handle (as in chlorination) or are effective against certain organisms, but not others. Fouling of cooling tower systems by algae and slimes results.

New No. 120 Series Algaecide succeeds when copper sulfate, potassium permanganate, quaternary ammonium compounds, sodium pentachlorophenate, and other complex chemicals offer only a partial solution to fouling conditions.

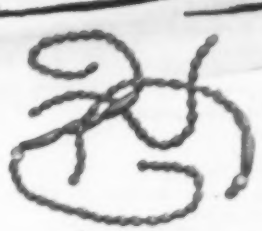
For complete information, call your A-C office, or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin, for Bulletin 28X8434.

As little as 2 ppm has killed all these algae



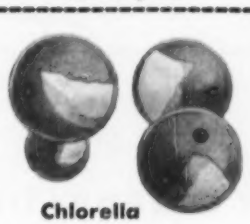
Hydrodictyon

Microcystis

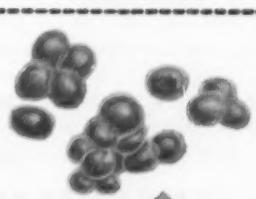


Anabaena

Oocystis



Chlorella



Protococcus

ALLIS-CHALMERS

A-5101

At last...the solution to

really tough

gas-cleaning problems

Sub-micron fumes are the **really tough** gas cleaning problems. These fumes cannot be economically or effectively controlled by conventional cleaning devices.

However, the Chemico P-A Venturi Scrubber is proving its success in solving these **really tough** problems in more than 150 commercial installations and in more than 70 pilot investigations.

The table lists some of these commercial installations. All of these **really tough** problems and many more are being solved with complete satisfaction to users of P-A Venturi Scrubbers.

PROCESS	DUST OR FUME	INSTALLED CAPACITY CFM
Incinerator—Flue Fed	Fly Ash	32,000
Incinerator—Sodium Disposal	Na_2O	9,000
Incinerator—Industrial	Radioactive Dust	6,000
Dry Ice & CO_2 Plants	Amine Recovery	72,400
CO_2 Gas for Process	Fly Ash	500
Boiler Flue Gas	Fly Ash & SO_2	4,300
Enamel Frit Furnace	Dust & HF	11,900
H_2SO_4 Concentrator	H_2SO_4	49,800
Copperas Roasting	H_2SO_4	34,250
Cobalt Ore Roasting	H_2SO_4	65,000
Chemico Wet Type Acid Plant	H_2SO_4	41,000
Chloro-Sulfonic Plant	H_2SO_4	600
Phosphoric Acid Plant	H_3PO_4	91,900
Phosphoric Acid Concentrator	H_3PO_4	194,000
Phosphor Copper Furnace	H_3PO_4	15,000
Smelting—Non-Ferrous		
Blast Furnace	Lead & Organic	12,000
Reverb. Furnace	Lead Compounds	23,500
Comb. Blast & Reverb.	Lead Compounds	7,000
Brass Furnace	Zinc Oxide	7,500
Ajax Furnace	Beryllium Fumes	4,000
Steel Plant		
Oxygen Steel Process	Iron Oxide	140,000
Blast Furnace	Coke & Iron Oxides	788,000
Zinc Sintering	Zinc Oxide	75,000
Wood Distillation	Tar Products	3,500
Na_2SiF_6 Dryer	SiF_4 & Dusts	700
Iron Chloride Concentrator	$FeCl_2$ & HCL Mist	40,000
Unknown	Carbon Black	1,700
Lime Kiln	Lime & Na_2O	18,000
Detergent Spray Dryer	Chemical Fume	250,000
Furfural Residue Burner	Fly Ash	36,000
Nodulizing Kiln	Manganese & Lead	25,000
Aluminum Pot Lines	Tar Fog, Fluorides	40,000
Carbide Furnace	Metal Oxides	1,000
Asphalt Plant	Rock Dust	80,000

Write to our P-A Sales Department for Bulletin M-102 describing the simple operating principle of the P-A Venturi Scrubber, and Bulletin M-103 explaining its metallurgical fume applications in the steel industry.

CHEMICAL CONSTRUCTION CORPORATION

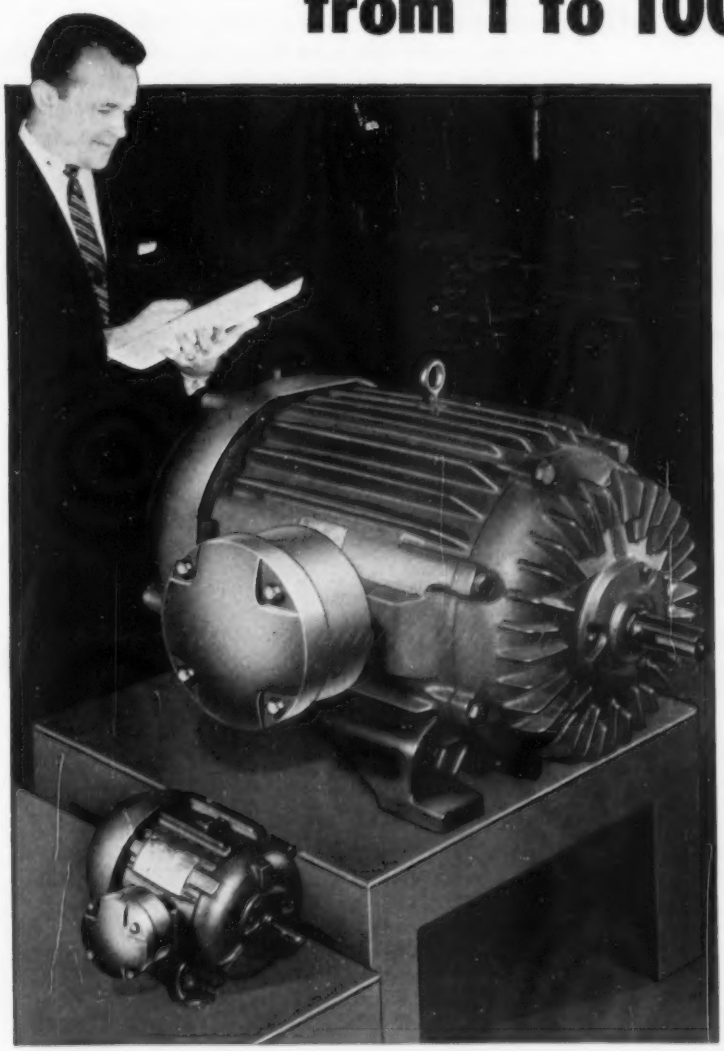
525 WEST 43rd STREET, NEW YORK 36, N. Y.
Technical Representatives Throughout the World
Telephone LOngacre 4-9400
Cable Address: CHEMICONST, N. Y.

-- 307

There's MORE rating selection available in Allis-Chalmers **MOTORS**

To meet refinery needs...

Allis-Chalmers Offers Complete Line of Rib-Type MOTORS from 1 to 100 Hp



Allis-Chalmers, a pioneer in rib-type TEFC motor design, is the only leading manufacturer offering a complete line of these motors from 1 to 100 hp. The many cost-saving features of deep-rib construction can be applied in a variety of uses . . . both indoors and out.

Here's why these motors can cut refinery costs:

MORE cooling surface — Rib-type design provides reserve cooling capacity in dirty locations.

MORE iron—Cast-iron frame and external parts assure rigidity and resistance to corrosion.

MORE copper — Allis-Chalmers greater use of copper increases electrical life.

MORE lubrication provisions — Large grease reservoirs surround bearings. Provision made for in-service relubrication — important where moisture or corrosive vapors contaminate grease.

As a new machinery component or as replacement, specify Allis-Chalmers. To find out more, contact your nearby Allis-Chalmers distributor, district office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

A-4962

ALLIS-CHALMERS

GASOLINE KEEPS ITS POWER IN STORAGE WHEN IT CONTAINS

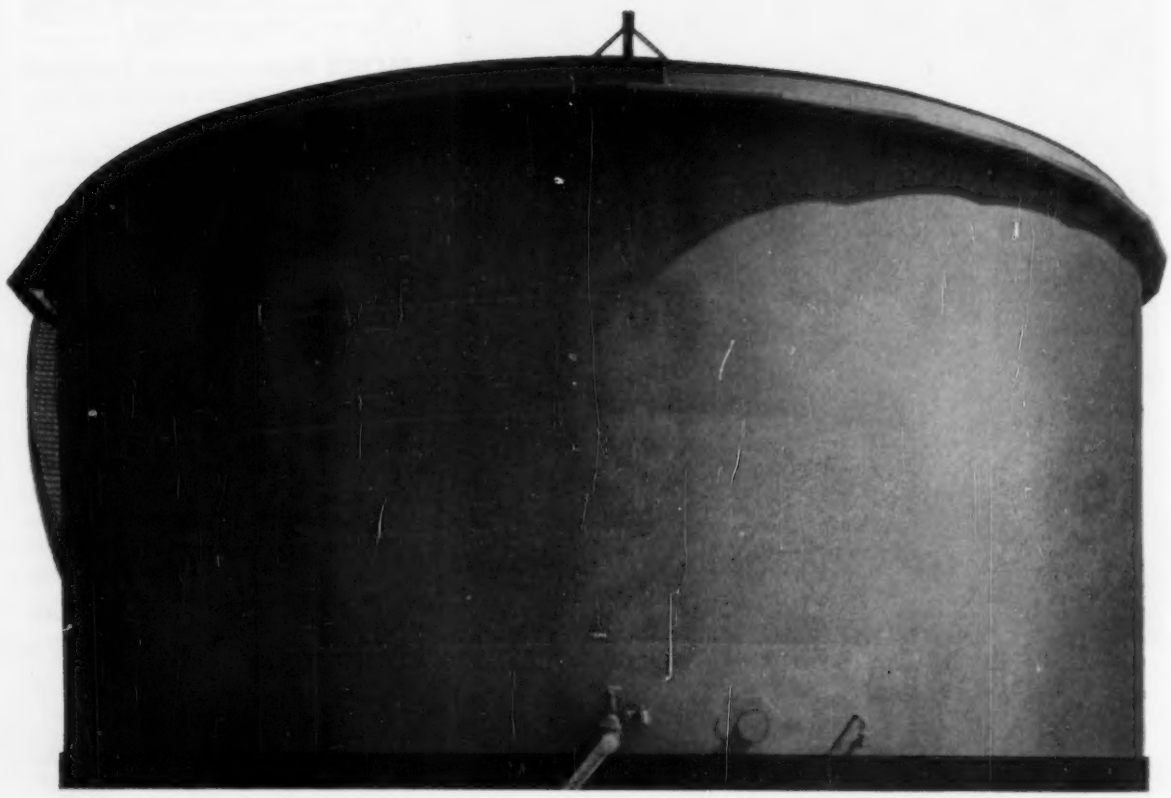
No matter how superior a gasoline you produce, the formation of gums in storage can rob it of its power. To protect the performance of your gasolines—to protect your sales—rely on Tenamene gum-inhibiting additives. Rely, too, on the interested technical service of Eastman petroleum specialists, ready to help solve your refinery inhibitor problems on the spot.

For more information on Tenamene additives and the service that backs up their proper use, contact our local representative or write to EASTMAN CHEMICAL PRODUCTS, INC., *subsidiary of Eastman Kodak Company,* KINGSPORT, TENNESSEE.

Tenamene

EASTMAN GASOLINE ADDITIVES

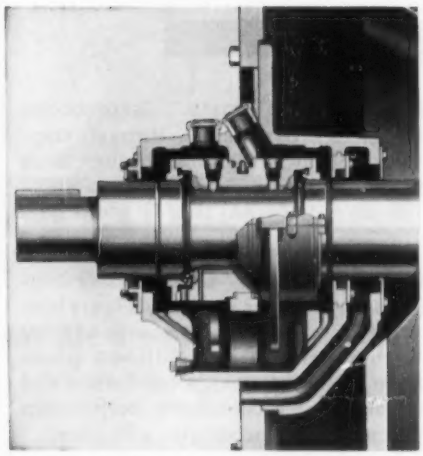
SALES OFFICES: Eastman Chemical Products, Inc. Kingsport, Tennessee; New York City; Framingham, Mass.; Cincinnati; Cleveland; Chicago; St. Louis; Houston. **West Coast: Wilson Meyer Co.,** San Francisco; Los Angeles; Portland; Salt Lake City; Seattle.



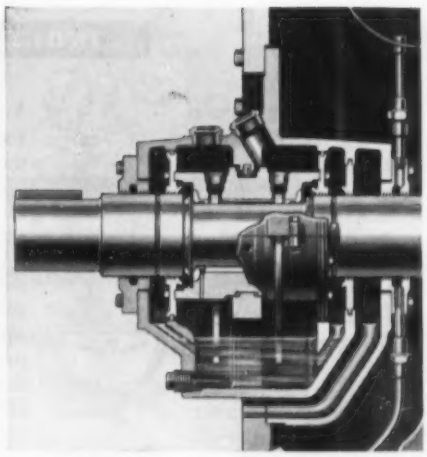
For more data on advertised products, use Readers' Service Cards, last page.

NEW Bearing Design Means Better Motor Performance

Allis-Chalmers capsule-type sleeve bearings now perfected for complete motor line



Standard capsule-type sleeve bearing



High speed capsule-type sleeve bearing

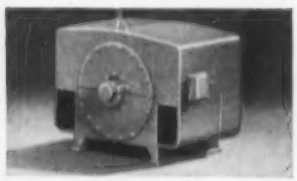
A new feature—an improved capsule-type bearing design—has been added to the Allis-Chalmers complete line of large end-shield bearing motors. This new bearing will give you better motor service, simplified maintenance and longer motor life through features like:

- Dust-tight, leakproof enclosure protects bearing from dirt, dust or abrasive materials.
- Venting system prevents oil leakage — keeps oil and vapor from getting into motor enclosure.
- Dual oil-rings insure bearing surface lubrication — either ring can adequately lubricate bearing.
- Split end-shield gives easy accessibility to winding and air gap — without disturbing capsule or bearing alignment.

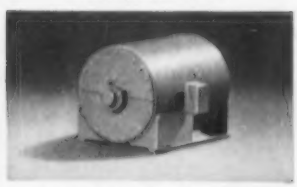
Drip-proof or splash-proof cage motor

Synchronous or wound-rotor motor

High speed cage motor



Weather-protected motor



Totally-enclosed fan-cooled motor

Totally-enclosed forced-ventilated motor

Water-cooled or inert-gas-filled motor

Capsule-type bearings are standard on these Allis-Chalmers motors.

You get MORE from Allis-Chalmers motors

More design and construction features — more application help. For complete information, contact your nearby A-C office or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

LIVE BETTER ELECTRICALLY

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5032

HOW TO FIGURE THE COST OF STEAM TRAPS

STEAM TRAPS are something like wives. First, there is the cost of securing one and installing it in its new home. Then, there is the cost of maintaining it. Now, everyone knows that some wives are frugal and help their husbands a great deal, while others are frivolous spendthrifts. It is the same way with steam traps. You have to figure the original installed cost, the maintenance cost and the effect on general operation.

Divide the total expenses by life of the trap and you get down to the real heart of the matter—the *cost per year.* This is where Armstrong steam traps really shine! Let's take a look at the details:

DIRECT TRAP COSTS

1. First Cost. The price of Armstrong traps is low in terms of capacity. An optimum relationship between leverage, bucket weight, bucket travel and orifice size gives big capacity in a small package. Armstrong steam trap capacity ratings are based on *actual* tests with condensate at steam temperature and with actual hookups. They tell you what the trap will deliver *on the job.* This is not generally the case with other trap ratings.

2. Installation Cost. In four of the most widely used sizes, Armstrong traps are available in either side inlet—side outlet or bottom inlet—top outlet body styles, making possible the simplest, lowest cost installation.

3. Maintenance Cost. 40% less maintenance with Armstrong traps is the average of all the maintenance reduction reports secured from users over a period of years. This is due to high quality of parts, generous safety factors and inverted bucket know-how.

4. Repair Parts Cost. Armstrong heat treated chrome steel valve parts, precision ground and lapped, last a long time. When they do require renewal, a complete new valve mechanism right off the factory production line transforms an old trap into a new one at low cost.

INDIRECT COSTS

1. Cost of Steam Waste. This cost occurs through leaky trap valves, through traps that stick open or lose prime, through extra hours of operating heat transfer equipment due to poor drainage. This is a cost you can eliminate with Armstrongs.

2. Cost of Efficiency Losses. Poor trapping cuts heat transfer efficiency. Figure how much 10% loss affects the return on a $5000 production unit, or a $1,000,000 plant. Armstrong traps discharge condensate and air as fast as it accumulates, keep steam equipment at peak productive efficiency.

3. Cost of Downtime. Armstrong traps stay on the job long and faithfully, eliminating the production losses caused by excessive downtime for maintenance.

A steam trap casts a mighty big shadow that is multiplied by the number of traps in a plant until it has a major effect on operating costs. When you figure the costs from all angles you will find it pays to specify "traps shall be Armstrong."

FREE: STEAM TRAP BOOK

—44 pages of prices, design, selection, installation and maintenance data on Armstrong steam traps. You are welcome to a copy. Call your local Armstrong Representative, or write.

ARMSTRONG MACHINE WORKS

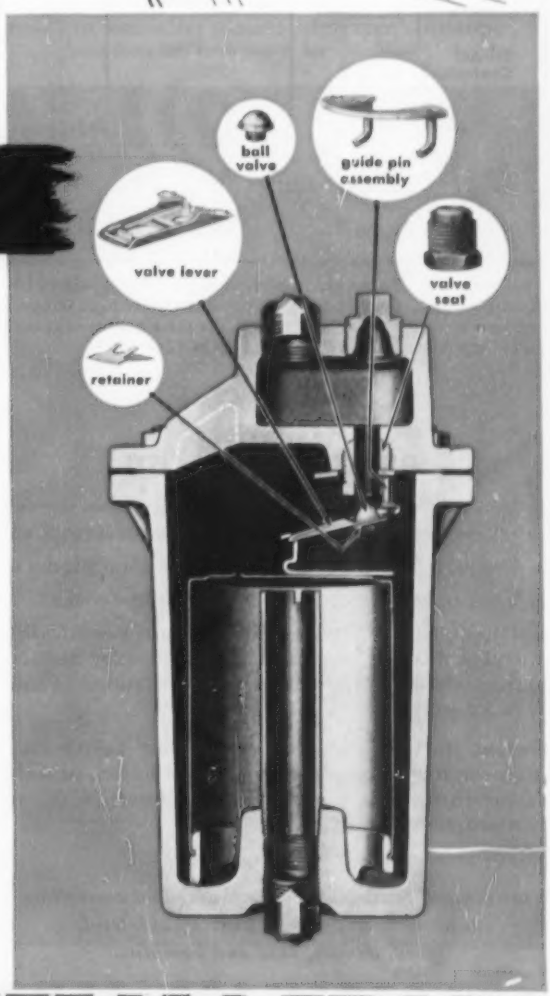
852 Maple Street • Three Rivers, Michigan

YOU CANNOT BUY A BETTER TRAP THAN AN ARMSTRONG . . .

Here Are Some Questions for Cost Comparison

1. Will the valve stay steam-tight for 2 to 3, or even up to 10 years depending on the service?
2. Will the trap discharge condensate at steam temperature to keep equipment hot and minimize non-productive radiation losses?
3. Will the trap automatically discharge air in sufficient volume to keep equipment at peak temperature and to prevent corrosion?
4. Is there enough safety margin of power in the bucket and lever to open the trap when the orifice enlarges slightly due to wear?
5. Can the trap stick in open position?
6. Is the trap apt to lose prime?
7. Are the published trap capacity ratings accurate and reliable for trap selection purposes?
8. Will the trap cleanse itself of ordinary dirt and scale?
9. Is the trap easy to install, inspect and repair?
10. Is the trap unconditionally guaranteed to give complete satisfaction?

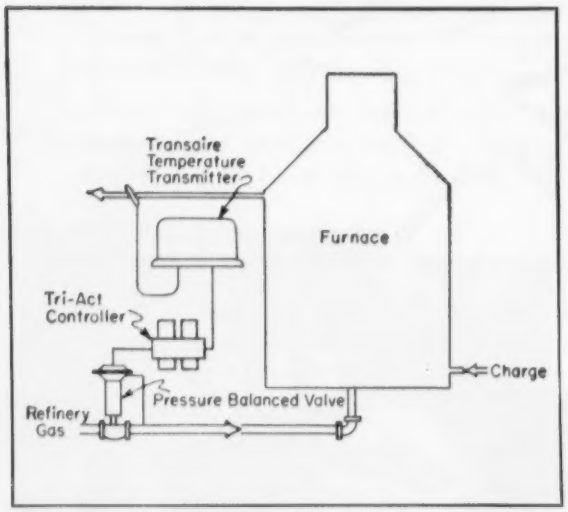
If the trap is an Armstrong, the answer to each of these questions is favorable!



ARMSTRONG STEAM TRAPS

For more data on advertised products, use Readers' Service Cards, last page.

See how *Taylor* can solve your furnace temperature control problem



The TRANSAIRE Transmitter, with its short range spans of 100, 200 or 400 °F. is particularly adaptable to these high temperature applications. In fact, it provides the same quality of control on cat crackers with temperatures up to 1200 °F.

FIELD experience has proven that there is no better control system on the market at any price for *Feed Preheaters to Reformer Reactors, Cat Crackers and Crude Units, and Furnaces for Column Reboilers and Hot Oil Circulating Systems.*

The combination of a Taylor TRANSAIRE* Temperature Transmitter and TRI-ACT* Controller gives practically instantaneous response and the right amount of correction to control the slightest temperature variation. Check these features:

1. Extreme sensitivity in the transmitter (1/10 of 1%) signals the minutest of process changes to controller.

2. SPEED-ACT* (rate action) response permits the signal from the transmitter to follow accurately the dynamic changes in process, overcoming inherent lags in process and well.

3. The sensitivity of the TRI-ACT controller (1/10 of 1%) provides instantaneous corrective valve action.

4. The TRI-ACT circuit (PRE-ACT* rate action ahead of reset and proportional) permits higher PRE-ACT settings which produce corrective valve action of just the right magnitude for straight line control.

The TRI-ACT controller is the *only* pneumatic controller that has such an advanced circuit.

BENEFITS TO YOU

1. You are able to maintain constant optimum temperatures on feeds to cat crackers, reformers, reactors, etc.

2. You obtain higher yields of specification product.

3. Your operating costs are substantially reduced.

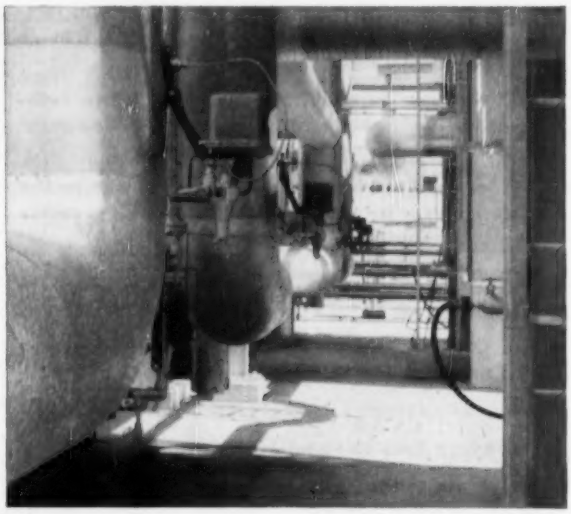
4. The on-stream life of your furnace is considerably extended because the TRI-ACT controller reduces coking which usually results from variations in load or fuel supply.

Present your specific problem to your Taylor Field Engineer for a sound, economical solution, or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

♦ ♦ ♦

Instruments for indicating, recording and controlling temperature, pressure flow, liquid level, speed, density, load and humidity.

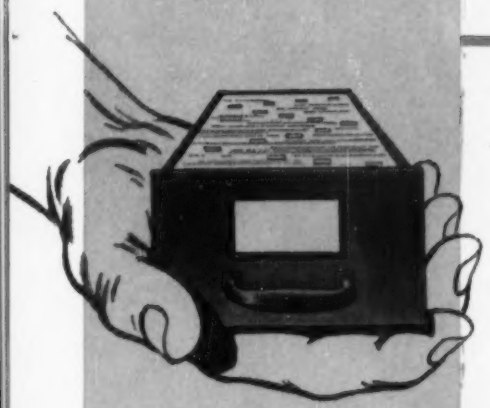
*Trade Mark



Taylor TRANSAIRE Temperature Transmitters in use on Reformer Reactor Pre-Heaters at a well-known South Western gasoline plant.

Taylor Instruments MEAN ACCURACY FIRST

With Our Experience



We think we can find the answer to your refinery tubing problems

Maybe we sound confident. But why not? Our tubing specialists have been meeting and solving refinery tubing problems for over 60 years—problems that deal with corrosion, oxidation, acids, high and low temperatures, pressures, exposures, etc. These case histories have been kept on file, and can be tapped for information at any time.

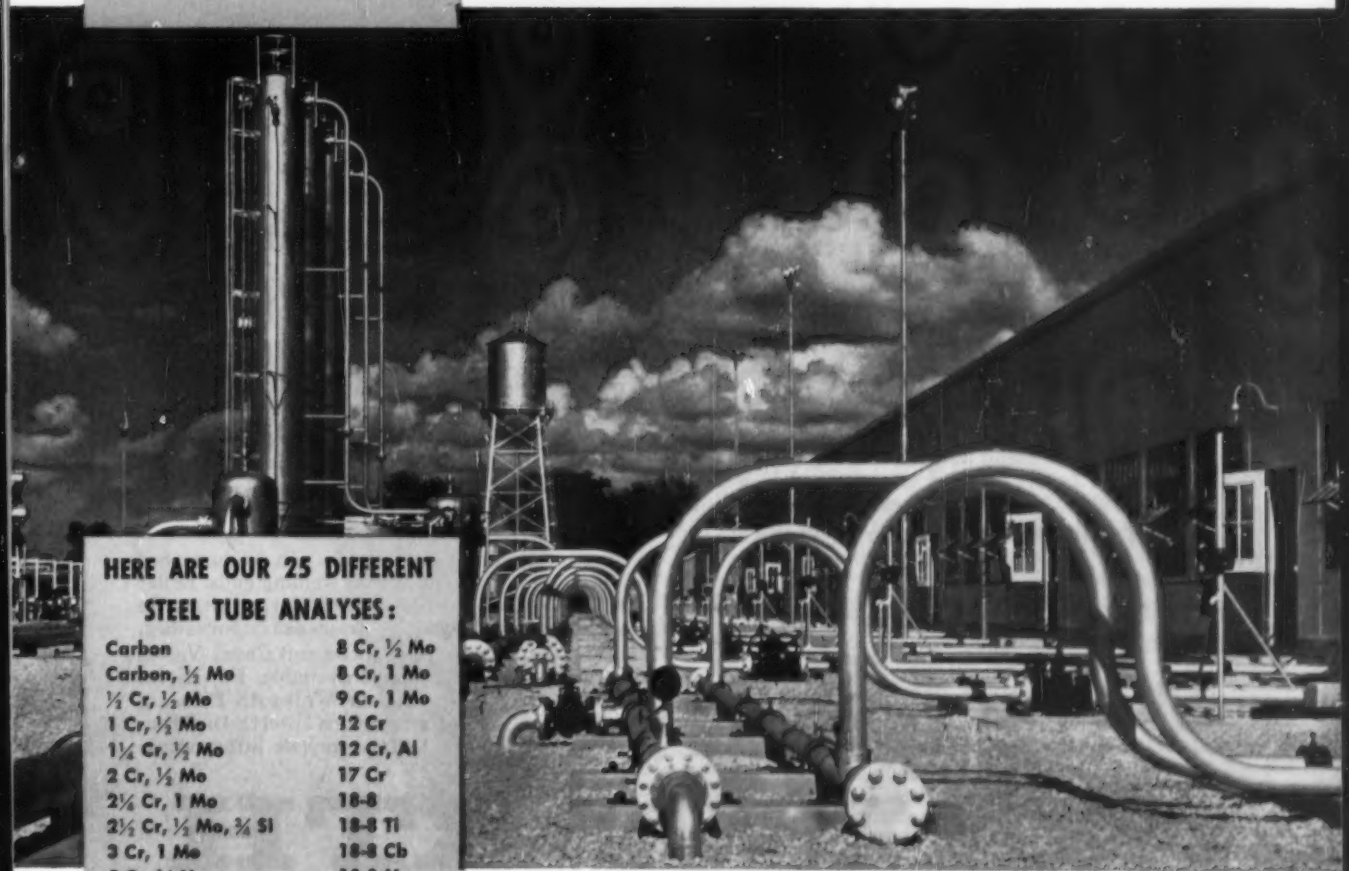
We've used this 60-year-experience file to develop the list of 25 steel analyses shown here. Each analysis was specifically-designed to combat certain refinery conditions, and each one has been tested time and again so that we know its exact capabilities and limitations. Other chemical compositions are also available in tubular products, and a wide variety of high temperature problems are now under study.

So you see why we feel confident to tackle any refinery tubing problem that comes along. Why not send us yours today?

Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

National Tube Division, United States Steel Corporation, Pittsburgh, Pa.
(Tubing Specialties)

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK



HERE ARE OUR 25 DIFFERENT STEEL TUBE ANALYSES:

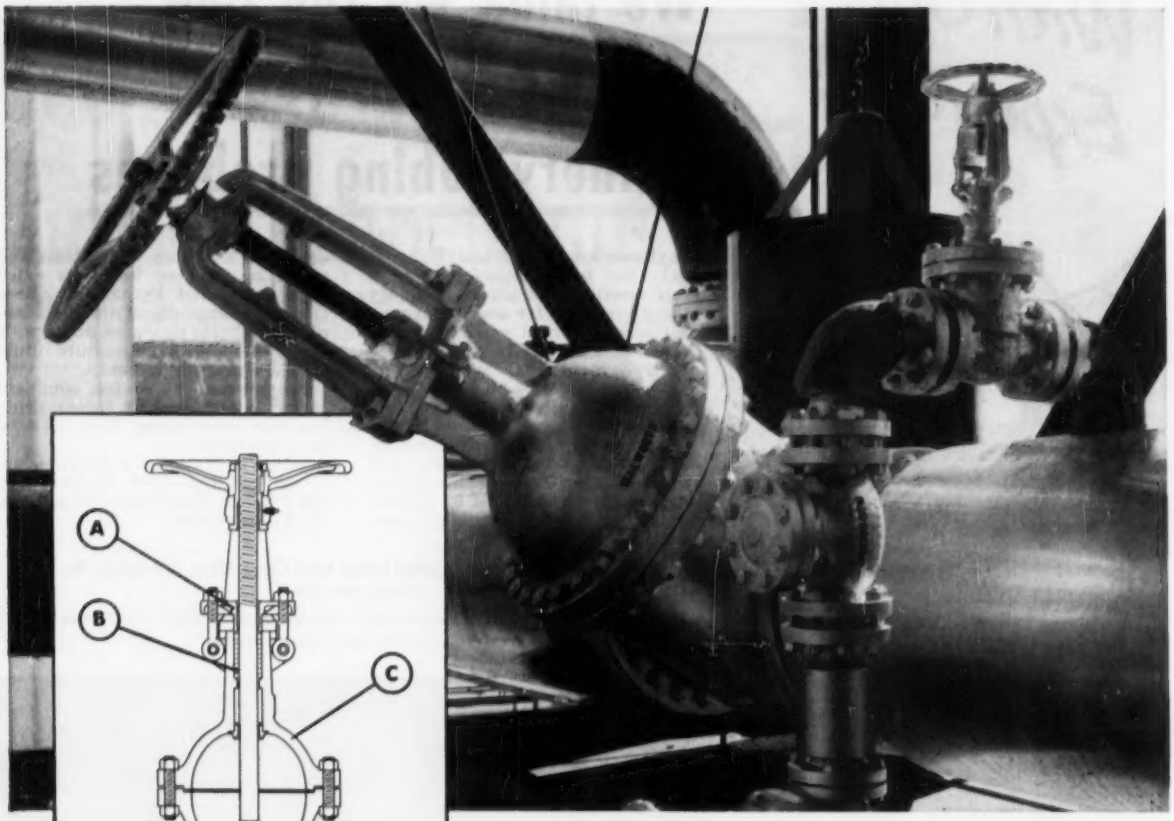
Carbon	8 Cr, ½ Mo
Carbon, ½ Mo	8 Cr, 1 Mo
½ Cr, ½ Mo	9 Cr, 1 Mo
1 Cr, ½ Mo	12 Cr
1¼ Cr, ½ Mo	12 Cr, Al
2 Cr, ½ Mo	17 Cr
2¼ Cr, 1 Mo	18-8
2½ Cr, ½ Mo, ¾ Si	18-8 Ti
3 Cr, 1 Mo	18-8 Cb
5 Cr, ½ Mo	18-8 Mo
5 Cr, ½ Mo, 1½ Si	25-20
7 Cr, ½ Mo	3½ Ni
5 Ni	

WALLS WITHOUT WELDS

NATIONAL SEAMLESS PIPE AND TUBES

USS

UNITED STATES STEEL



Walworth Series 150 and 300

CAST STEEL GATE VALVES OFFER YOU THESE FEATURES

for 'round-the-plant service

(A) GLANDS: Clearances between the gland and stuffing box, and gland and stem, are such that the stem cannot be scored even if the gland is pulled down unevenly.

(B) DEEP STUFFING BOXES: More than adequate in all sizes (2" to 24") to assure tightness and maximum packing life.

(C) BONNETS AND BODIES: Engineered to exceed the requirements of all applicable codes and standards. They are tough, durable, dependable.

(D) INTEGRAL GUIDE RIB FACES IN BODY: Machined to insure accurate centering of the gate.

(E) STURDY SEAT RINGS: Bottom-seated so that no recess exists at the back of the ring to cause turbulence, erosion and pressure drop.

(F) STREAMLINED PORTS: Permit unobstructed flow which results in minimum pressure drop and reduces the possibility of erosion.

Walworth Cast Steel Gate Valves can be furnished with either flanged ends or butt welding ends. Roller bearing yokes are available on the larger sizes. On valves 4 inches and larger, by-passes can be furnished. Walworth Cast Steel Gate, Globe and Check Valves from Series 150 to 2500, are available. For Series 600 and higher, we recommend Walworth Pressure Seal Cast Steel Valves. See your Walworth Distributor or write to Walworth for complete information.

WALWORTH

60 East 42nd Street, New York 17, New York

SUBSIDIARIES: ALLOYCO ALLOY STEEL PRODUCTS CO. CONOFLOW CORPORATION M&H M & H VALVE & FITTINGS CO. SW SOUTHWEST FABRICATING & WELDING CO., INC. WALWORTH COMPANY OF CANADA, LTD.

WOLVERINE FIELD ENGINEERS

answer questions about

TRUFIN* TYPE S/T

condenser tube

Frequently, Wolverine Field engineers are asked this question:

In what type of application is Wolverine Trufin* Type S/T most advantageous and to what extent?

Their answer: **Trufin offers most advantages when used for change of phase services such as condensation and vaporization.**

CONDENSATION: The rate of condensation is closely related to the thickness of the condensate film which collects on the tubes; the thicker the film—the lower the rate. The action of Trufin, cutting through the condensate film, restricts the thickness to which the film can build up. The result is an appreciable gain over the condensing rate obtainable with the same number of square feet of prime surface tube.

VAPORIZATION: For such units as reboilers and evaporators, Trufin offers tremendous advantages although the reason and mechanism naturally differ from fluid-to-fluid heat transfer. The convection is much more vigorous and the vaporization transfer rate is higher because a square foot of Trufin surface occupies much less volume than a square foot of plain tube surface.

Furthermore, the upper edges of the fins preferentially serve for bubble nucleation; thus, the bulk of the surface is less susceptible to vapor binding than plain tube surface and heat flux limitations are not decreased by the reduced volume of the exchanger.

The advantages of Wolverine Trufin Type S/T over plain surface tube can vary from a small percentage to gains of 100% on a lineal foot basis depending on the type of application. For ideal conditions such as those that exist in some hydrocarbon condensers and reboilers, the increase in effectiveness can actually be greater than the outside area ratio of Trufin over plain tube.

Similar information along with valuable design data is contained in Wolverine's Trufin Opportunity Book. Write for your copy today.

WOLVERINE TUBE, 1437 Central Avenue, Detroit 9, Michigan.

*REG. U. S. PAT. OFF.

DIVISIONS OF
CALUMET & HECLA, INC.

CALUMET DIVISION
WOLVERINE TUBE DIVISION
CANADA VULCANIZER
& EQUIPMENT CO. LTD.
FOREST INDUSTRIES DIVISION
GOODMAN LUMBER CO.

WOLVERINE TUBE

Division of Calumet & Hecla, Inc.

Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES.

EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK.

NEWS ITEM . . .

Gulf Coast refinery engulfed by capacity demands of kerosene cooler

Solved by

RETUBING with WOLVERINE TRUFIN* TYPE S/T

From a first class bottleneck to a unit producing 80% more than original capacity is the story of a kerosene cooler in the process line of a Gulf Coast refinery.

The cooler, a plain tube unit, was unable to keep up with the refinery's constantly increasing production demands. There were two ways in which refinery engineers could handle the situation:

(1) A new and larger unit could be designed and built.

(2) The existing unit could be retubed with Wolverine Trufin Type S/T—the integral finned condenser tube.

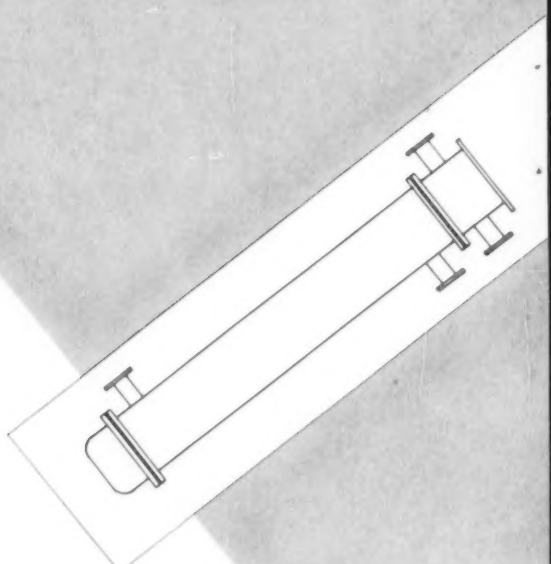
After careful consideration it was decided to retube with Wolverine Trufin. The results were immediate and highly satisfactory. Production on the cooler could be increased by a full 80%—and the bottleneck was a thing of the past. In addition the refinery realized substantial savings in time plus the elimination of the costs of designing and building a new unit.

The reason for Trufin's ability to boost heat transfer performance is found in its integral fins—extruded directly from the tube wall. Because of this, Trufin S/T has approximately twice the heat transfer surface of plain tube—extracts more BTU's per foot of tube.

Trufin Type S/T is completely interchangeable with prime surface tube using standard tools and retubing techniques.

If your plant has similar bottlenecks, Wolverine Trufin Type S/T condenser tube can help you solve them. Next time you retube, specify Trufin—watch production go up and costs stay down. Wolverine's new Process Flowsheet Catalog is filled with process drawings of actual Trufin installations. Write for your copy today.

WOLVERINE TUBE, 1437 Central Avenue, Detroit 9, Michigan.



Wolverine Trufin available in Canada through the Unifin Tube Company, London, Ontario.

DIVISIONS OF CALUMET & HECLA, INC.
CALUMET DIVISION
WOLVERINE TUBE DIVISION
CANADA VULCANIZER & EQUIPMENT CO., LTD.
FOREST INDUSTRIES DIVISION
GOODMAN LUMBER CO.

WOLVERINE TUBE

Division of Calumet & Hecla, Inc.

Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

*REG. U. S. PAT. OFF.

56TW52—5265

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA. SALES OFFICES IN PRINCIPAL CITIES.

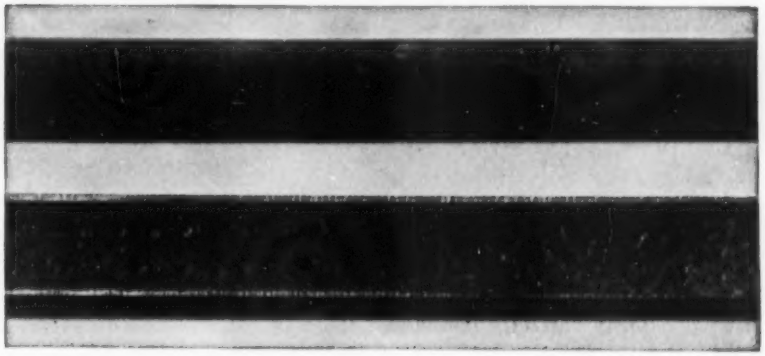
EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK.

BRIDGEPORT BRASS COMPANY

CONDENSER AND HEAT EXCHANGER TUBE EDITION

COPPER ALLOY BULLETIN

Bridgeport Brass Co. — MILLS IN BRIDGEPORT, CONN. AND INDIANAPOLIS, IND.—IN CANADA: NORANDA COPPER AND BRASS LIMITED, MONTREAL



Sections of low-carbon steel condenser tube showing extensive effects of rust and corrosion on the water side in comparison to the unaffected surface of the ammonia side.

Duplex Tubes In Ammonia Condensers Can Cut Power Costs Up To 25%

The use of ammonia and other refrigerants in refrigeration systems has increased tremendously in recent years. Many problems—old and new—involving the handling of corrosive gases and liquids continue to crop up in domestic, industrial, processing, chemical and refining applications of refrigeration and air conditioning. It is important that we learn how to handle these corrosive gases and liquids.

In general, condenser tubes in refrigeration systems are subjected to dual corrosion; that is, one type of corrosive action inside the tube, an entirely different type on the exterior side. For this reason Bridgeport Duplex Tubes—with one metal inside and a different metal outside—are finding ever-wider application in the solution of these complex corrosion problems.

Ammonia Refrigeration

Although dry ammonia gas is not corrosive to many metals and alloys, it is not always used in the completely dry condition. When ammonia contains dissolved salts, water, air or other common contaminants, it severely attacks copper and copper-base alloys.

Steel, on the other hand, is very resistant to ammonia corrosion, and is widely used in equipment handling ammonia (both anhydrous and moist). However, low-carbon steel tubes have a major shortcoming that prevents their being the universal answer to ammonia refrigeration corrosion problems, namely; water corrosion.

Corrosion from the water or brine side has always been a problem with low-carbon steel tubes. While steel tubes are satisfactory in withstanding corrosion from the *ammonia* side, the water side rusts quickly... builds up a heat-insulating layer which must be removed from time to time at considerable cost.

This problem is now being overcome through the installation of Duplex Tubes composed of low-carbon steel to the ammonia side, and copper or copper-base alloys, on the water side. For circulating fresh water—Admiralty #30, Red Brass #85, or Copper are recommended. Where sea water is used for cooling, Aluminum Brass #54, Duronze IV #53 (Arsenical Aluminum Bronze) and Admiralty #30 are preferred because of their greater resistance to dezincification corrosion, and general corrosion by sea water. When velocity of sea water is comparatively high, greater resistance to impingement corrosion is given by Duronze IV #53 and Aluminum Brass #54.

With Freon and methyl chloride refrigerants in a dry condition, copper and copper-base alloys have proved very satisfactory for corrosion resistance and long tube life. Arsenical Admiralty #30 or Aluminum Brass #54 are recommended for installations using sea water as the coolant. Copper, Red Brass, Admiralty, etc. are popular for fresh-water installations.

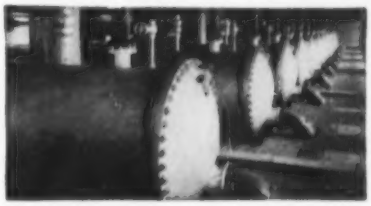
How Bridgeport Duplex Tubes Can Save You Money

Improved Heat Transfer. Mechanical bonding between the two components of Duplex Tubes is so tight that very satisfactory heat-transfer characteristics result. In addition, slime, algae and marine growths have less tendency to foul copper-base alloys than steel. Using copper or copper alloys on the water side therefore improves heat transfer because single-wall steel tubes pile up a thick insulating coat of rust which lowers heat-transfer value.

Reduced Maintenance, Shutdown Time and Labor. An ice company that replaced its steel tubes with Duplex (steel/Admiralty) reported two years later that four semi-annual cleanings were avoided...operating pressures are running 15 to 2 pounds lower... and that their Duplex Tubes have already paid for themselves.

Cut Power Costs! Replacement of corroded steel tubes in ammonia condensers has reduced power costs in some cases as much as 25%.

Greater Corrosion Resistance. Corrosion from water is often most severe at the inlet end of steel tubes, where turbulence is highest. Duplex Tubes will give greater corrosion resistance toward scale-forming waters which have been treated. And often in untreated raw waters—which would corrode low-carbon and stainless steels—Duplex Tubes can be used successfully.

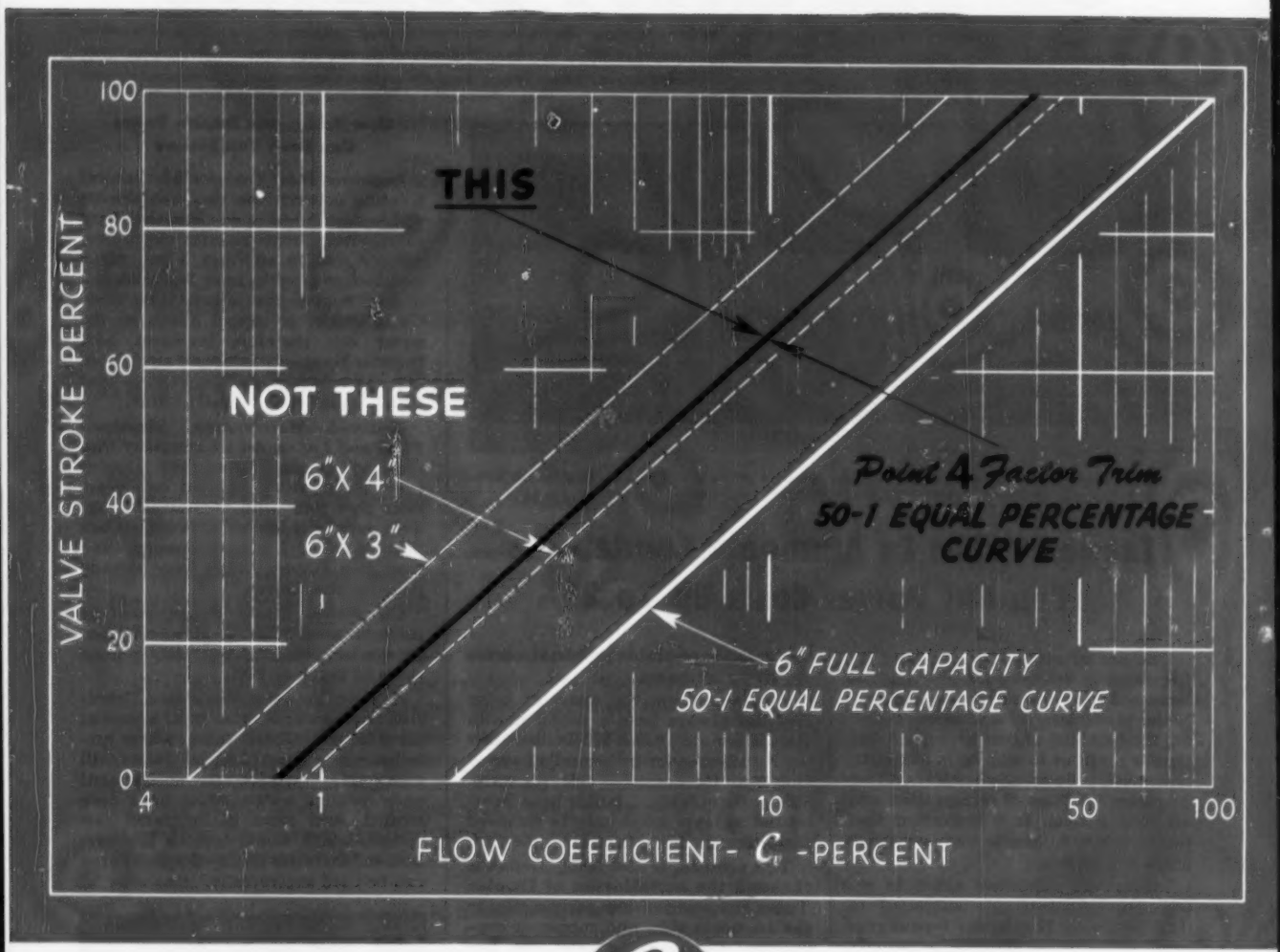


Ammonia condensers equipped with Steel/Copper Duplex Tubes—Courtesy York Corporation.

More Than 100 Combinations

Bridgeport produces a wide variety of alloys, from which more than 100 Duplex Tube combinations can be manufactured. Specialists in our Corrosion Laboratory will gladly assist you in determining the condenser tube alloy that will give the best service in your specific application. Please write or phone your nearest Bridgeport Sales Office today for this expert assistance, and for delivery of Bridgeport high-quality copper alloys. (1198)

One Size...



A HIGH C_Q (Quality Coefficient) PRODUCT

Point 4 Factor Trim

is the answer to those few types of applications where reduced capacity trim is required. It is available in V-port and solid turned designs for double or single seated valves and in a wide variety of materials. Send for Data Sheet No. 10-5.

For more data on advertised products, use Readers' Service Cards, last page.

Not Two

Masoneilan *Point 4 Factor Trim* offers the ONLY REALISTIC approach to selection of reduced capacity trim

It is a DEMONSTRABLE Fact that for a given size top-and-bottom guided valve only *one* size reduced capacity trim is:

Desirable from an engineering standpoint because . . .

(a) properly designed wide-range valves with full capacity trim will handle a vast majority of control problems.

(b) if any reduction is required, it must be substantial to be of any advantage.

(c) any sound design must be based on a reduction in seat ring diameter.

(d) rule-of-thumb trim reductions based on nominal *pipe* sizes are unnecessary and merely complicate the sizing problem.

Practical from manufacturing and operating standpoint because . . .

(a) mechanical strength is retained with standard guide and stem diameters and standard stroke, in combination with maximum reduction in seat diameter.

(b) reduction in number of parts simplifies stock problem.

(c) forged and cast forms insure complete uniformity of parts.

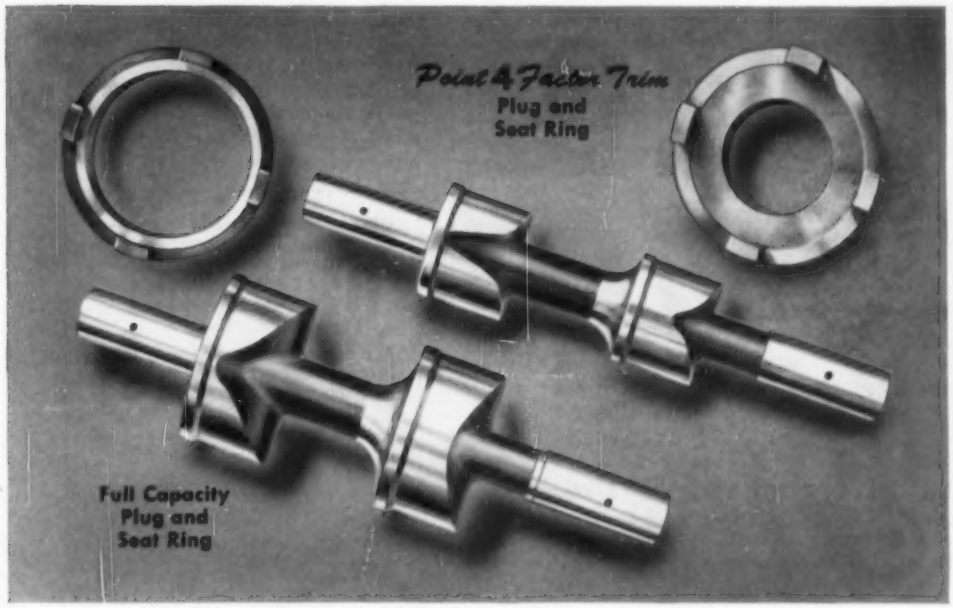
MASONEILAN

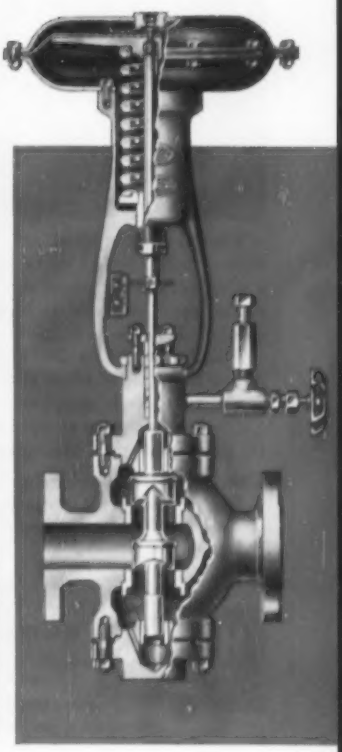
MASON-NEILAN

Division of Worthington Corporation

51 MAHATAN STREET, NORWOOD, MASSACHUSETTS

Sales Offices or Distributors in the Following Cities: New York • Syracuse • Chicago • St. Louis • Tulsa • Philadelphia • Houston • Pittsburgh • Atlanta • Cleveland • Cincinnati • Livonia • San Francisco • Boise • Louisville • Salt Lake City • El Paso • Albuquerque • Odessa • Charlotte • Los Angeles • Corpus Christi • Denver • Appleton • Birmingham • New Orleans • Dallas • Seattle • Mason-Neilan Regulator Co., Ltd., Montreal and Toronto





For more data on advertised products, use Readers' Service Cards, last page.

BRIEFS
for caustic soda buyers

New booklet
Barge delivery
Flake sizes
Drum styles

Useful facts on buying caustic soda are at your fingertips in this new pocket-size booklet.

Title: *Caustic Soda Buyer's Guide.*

Contents include a list of reasons *pro* and *con* switching from 50% to 73% liquid caustic.

There's a factual discussion of the comparative economics of both strengths, including a handy nomograph to help you figure which strength is your better buy.

The booklet also contains a nomograph that helps you estimate your liquid caustic requirements for various process solutions.

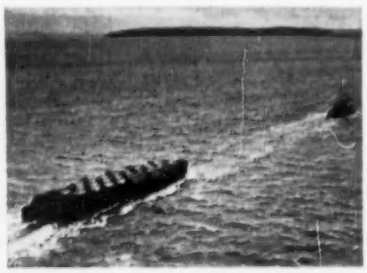
There's information on solid and flake caustic, too. Two tables show at a glance the dimensions and capacities of the many containers in which you can buy Hooker caustic soda.

Finally, there's a list of important points to consider when you're looking for a caustic soda supplier.

Check the coupon at right for a copy. Or write us if you'd like more than one.

Can you save buying by barge?

If you use large tonnages of 50% liquid caustic soda, and can receive by



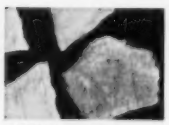
water, you may cut freight and handling costs substantially with barge service.

All Hooker plants and caustic terminals offer barge service as well as tank car service, since all are located on deep water.

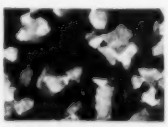
If you think there's a possible saving here, one of our representatives will be glad to discuss barge delivery with you.

Which flake size? It's easy to be sure of the best possible caustic soda flake size for your process, when you buy Hooker caustic.

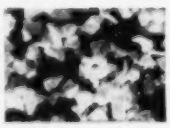
You have your choice of the four sizes here—all shown actual size.



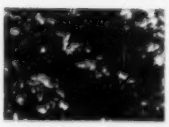
REGULAR



FINE



CRYSTAL



POWDERED

Regular, fine, and *crystal* flake are non-dusting—carefully screened for uniformity. We're extra-fussy about flake *thickness,* too. These flakes are hefty enough to take the jolts and jouncing of transit, and still reach you at full size. Yet they're thin enough to dissolve quickly when you're ready to put them to work.

For advice on the best flake size for your needs, write us, outlining the intended use.

Which drum style? You can order Hooker flake caustic soda in either of two drum styles.

The widely-used 400-pound drum shown above has a 14-inch opening that makes emptying safe and easy. The lid clamps on tight to protect contents in transit and storage.

Or you may prefer the full-open-head drum (not shown here). It gives you extra convenience in handling, and you can re-use the drum for many purposes. It costs a bit more than the 14-inch-opening drum.

Check items you'd like to receive:
- ☐ *Caustic Soda Buyer's Guide*
- Technical data on:
- ☐ 50% Liquid Caustic Soda
- ☐ 73% Liquid Caustic Soda
- ☐ Flake Caustic Soda

For information on these other Hooker chemicals used in the petroleum industry, check below:
- ☐ Aluminum Chloride, anhydrous
- ☐ Antimony Trichloride
- ☐ Muriatic Acid
- ☐ Sulfur Monochloride
- ☐ Sulfur Dichloride

Clip and mail to us with your name, title, company address.

HOOKER CHEMICALS PLASTICS

HOOKER ELECTROCHEMICAL COMPANY

1607 FORTY-SEVENTH STREET, NIAGARA FALLS, N. Y.

NIAGARA FALLS · TACOMA · MONTAGUE, MICH. · NEW YORK · CHICAGO · LOS ANGELES

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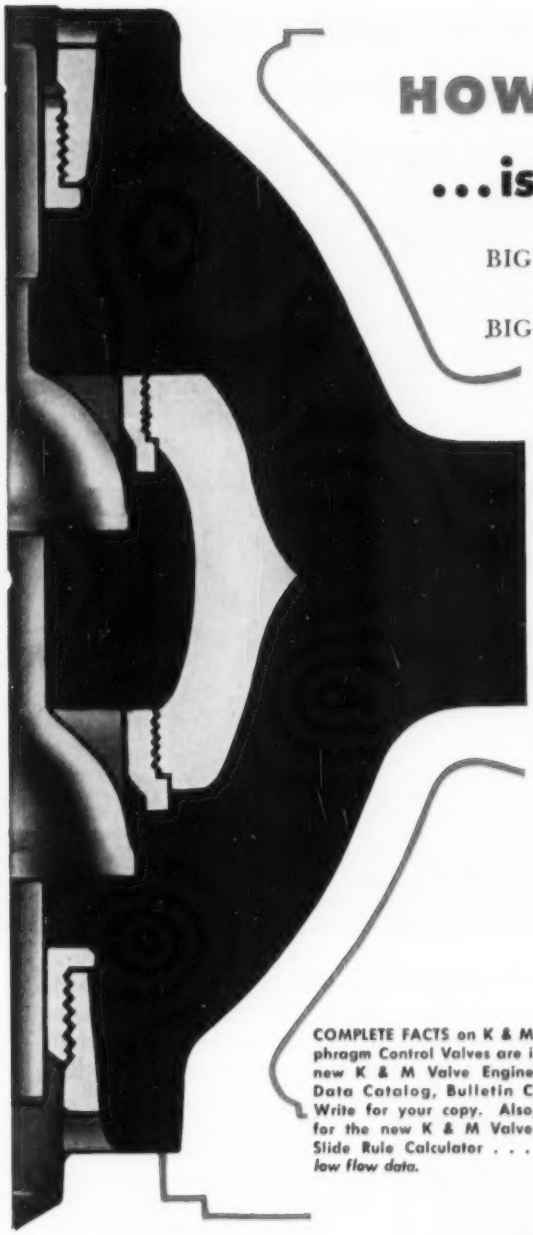


HOW BIG

...is a K & M six-inch valve?

BIG enough to pass 500 gpm of cold water through the valve body at a constant drop of one pound pressure.

BIG enough to provide the largest flow coefficient available in a standard six-inch diaphragm control valve.

Body flow passages of all K & M valves, for example, actually average 140% of cross-sectional pipe area. There's more space for fluid to flow . . . smoothly, freely and without turbulence. Frequently a smaller nominal size K & M Valve provides sufficient capacity to satisfy requirements that formerly called for a larger, more expensive valve.

Inner valve open areas, on the other hand, average only 80% of cross-sectional pipe area. Therefore, flow restrictions occur principally across the inner valve . . . where the restriction is controllable throughout the entire range of valve stem travel.

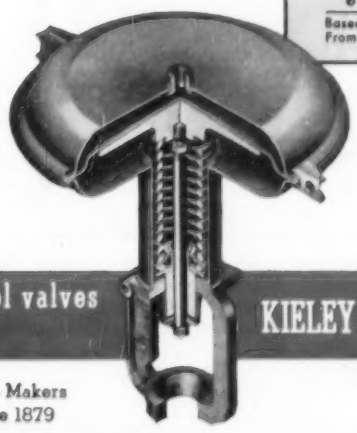
This K & M design often permits lower initial costs . . . always contributes to more precise flow regulation through the K & M Inner Valve.

COMPLETE FACTS on K & M Diaphragm Control Valves are in the new K & M Valve Engineering Data Catalog, Bulletin CV53. Write for your copy. Also, ask for the new K & M Valve Size Slide Rule Calculator . . . with *low flow data.*

C_V COMPARISON TABLE

Valve Size	K & M	Valve B	Valve C
¾"	10.9	8.4	8
1"	17.3	14.9	12
1½"	39.1	33.2	28
2"	61	57	48
2½"	97.7	71.0	72
3"	150	116	100
4"	219	197	165
6"	500	364	360

Based on the maximum C_V at rated travel through the valve body. From manufacturers most recent slide rules or tables.



diaphragm control valves

K&M

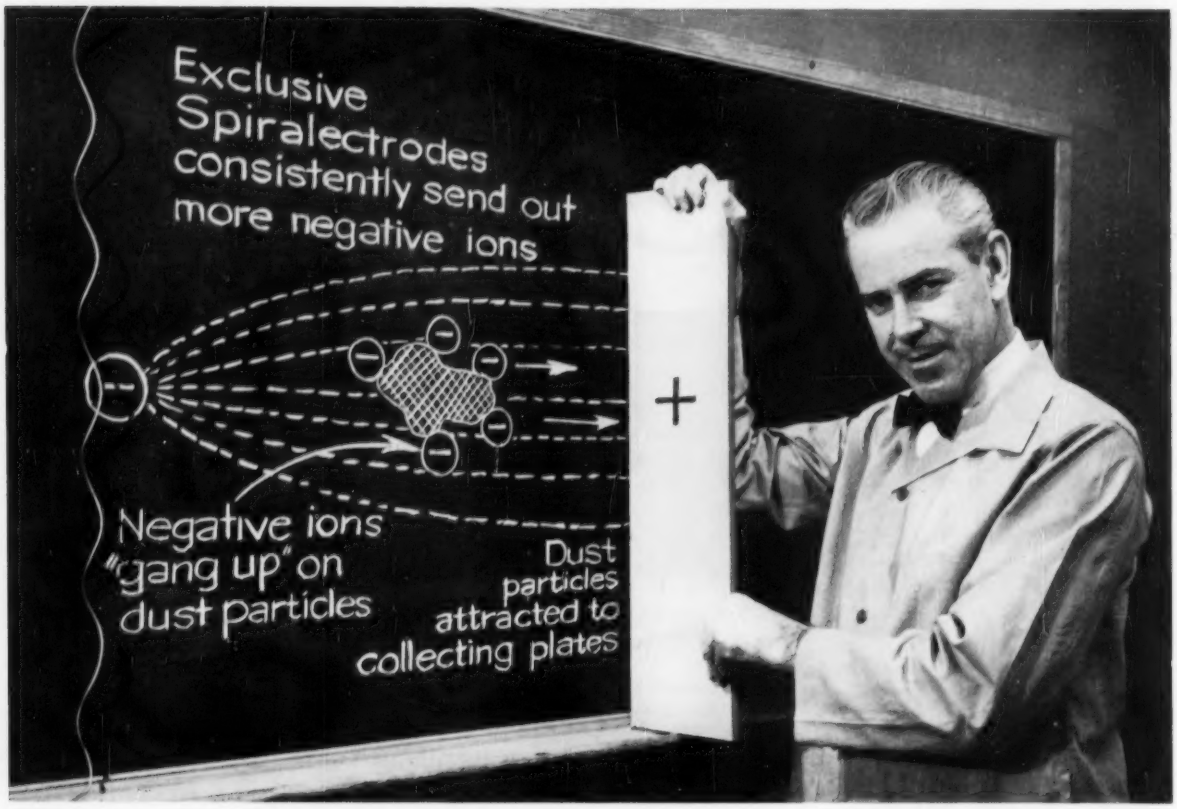
Valve Makers Since 1879

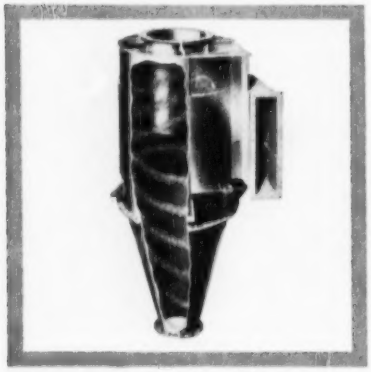
KIELEY & MUELLER, INC.

64 Genung Street
Middletown, New York

For more data on advertised products, use Readers' Service Cards, last page.

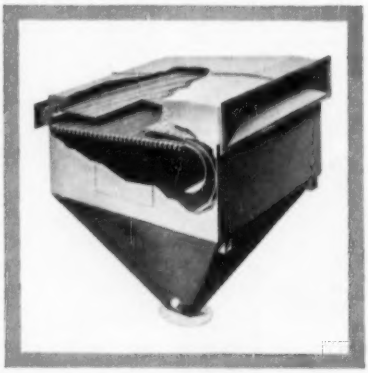
How a Buell Collection System "gangs-up" on dust to meet the toughest air pollution codes





Buell Cyclones also deliver extra collection efficiency to "gang-up" on dust: Exclusive Shave-off design harnesses double-eddy current and puts it to work.

With positive gas flow control for peak efficiency . . . plus continuous cycle rapping to eliminate puffing . . . Buell's "SF" Electric Precipitator really "gangs-up" on dust (even dust with high resistivity) to permit full production even under the most rigid anti-air-pollution codes.



Buell's Low Resistance Fly Ash Collector combines high efficiency to meet present day strictness, with low draft loss for natural or mechanical draft installations.

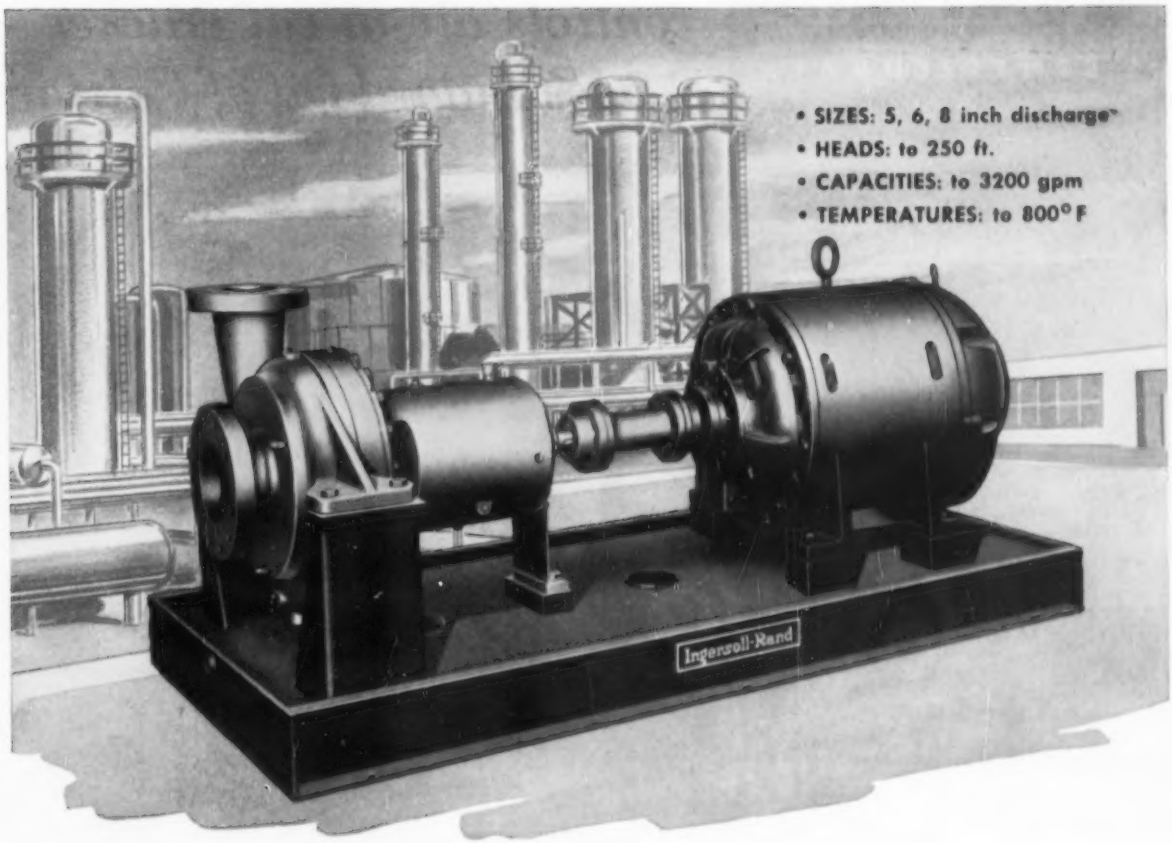
FOR THE COMPLETE STORY
Write:
Buell Engineering Company
Dept. 21-G, 70 Pine Street
New York 5, New York

buell®

MECHANICAL ELECTRICAL

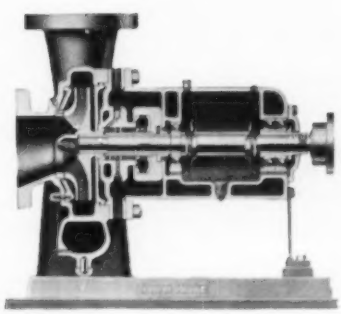
Experts at delivering Extra Efficiency in **DUST COLLECTION SYSTEMS**

For more data on advertised products, use Readers' Service Cards, last page.



BUILT TO DO THE JOB

in large capacity slurry pumping



Ingersoll-Rand closed-impeller Class BSFL slurry pump arranged for injection at the vertical ring fit.

Ask for Bulletin 7094-B

Ingersoll-Rand's vertically-split, Class BSFL, refinery pump shown above has established an enviable record for continuous, dependable performance.

Available in conventional or special slurry pump construction, it is recommended wherever large capacities are required at medium operating heads. Here's the pump you'll find in wide use for bottom circulation or slurry service.

As a slurry pump, the unit can be furnished with either open or closed impeller. Both types have renewable shrouds that protect the casing at front and rear of impeller, and an adjustable thrust bearing journal sleeve to maintain proper clearance with the front shroud or casing ring. A flushing connection to the throat bushing provides for clean oil injection, minimizing packing and sleeve wear.

Let our engineer give you complete details about these and the many other pumps in our complete refinery line.

Ingersoll-Rand IR

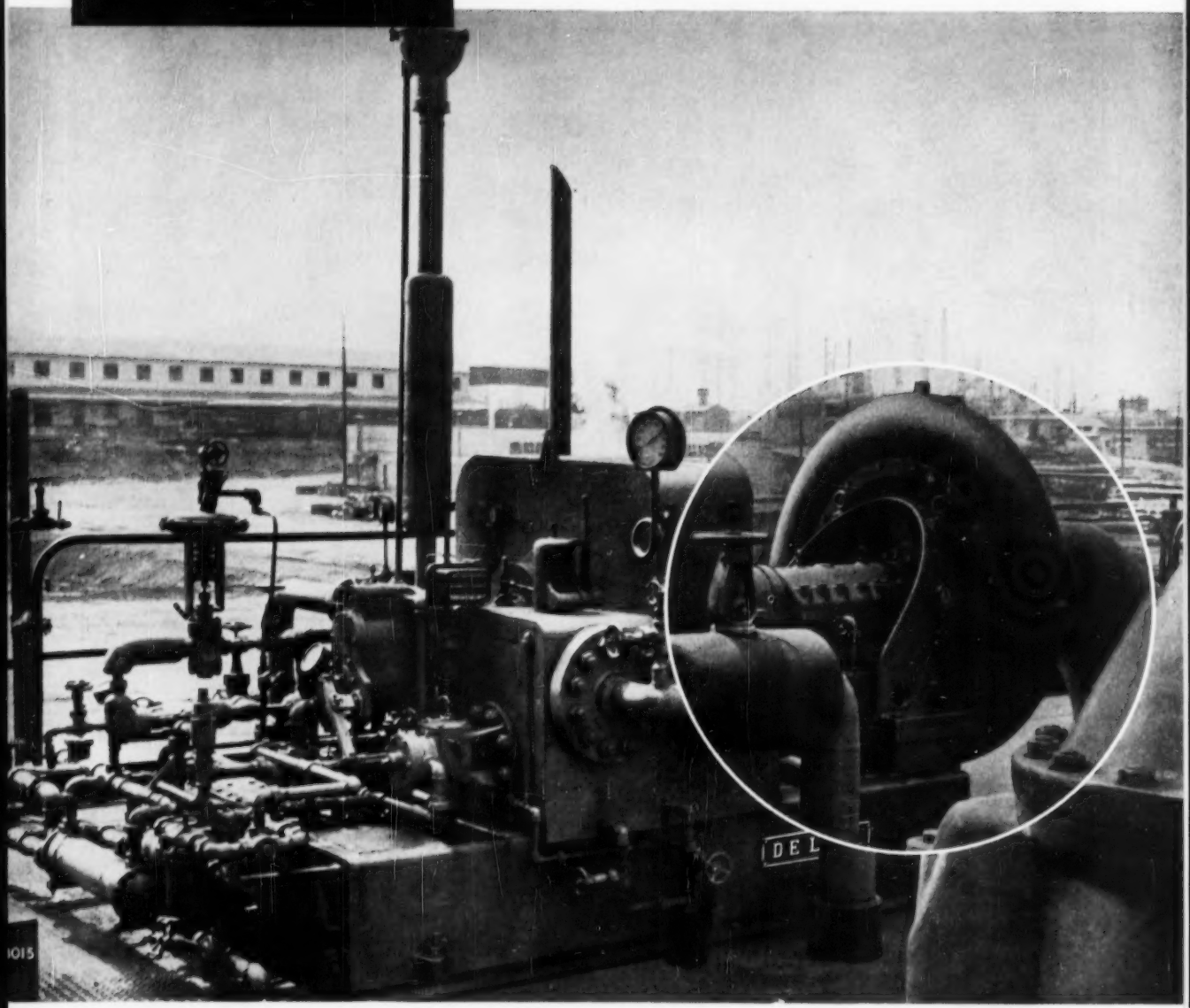
10-377

11 BROADWAY, NEW YORK 4, N.Y.

PUMPS • COMPRESSORS • ROCK DRILLS • VACUUM EQUIPMENT • CONDENSERS • AIR AND ELECTRIC TOOLS

DE LAVAL
CENTRIFUGAL
BLOWER

controls air in cat cracker at Standard Oil of California



This De Laval centrifugal blower, selected by the Fluor Corporation, is on stream at the Standard Oil Company of California's new cat cracker in El Segundo. For control air service, this blower delivers 9,500 cfm; inlet pressure is 15.4 psig and discharge pressure 19.4 psig. The blower is driven by a De Laval 220 brake horsepower MCP Turbine operating at 300 psig with a temperature of 650 F; it has all labyrinth shaft packing for high back pressure service.

In addition to single stage designs, De Laval makes a complete line of equipment for all refinery services, including multi-stage compressors driven by De Laval multi-stage turbines for condensing, non-condensing and automatic extraction applications.

Send for new Bulletin 0504

DE LAVAL *Centrifugal Blowers*

DE LAVAL STEAM TURBINE COMPANY
811 Nottingham Way, Trenton 2, New Jersey

DL 220

choose from 3 approaches to higher octanes with ISO-PLUS HOUDRIFORMING

The new HOUDRY ISO-PLUS Process combines the proved advantages of catalytic HOUDRIFORMING with other processes to economically reform low-octane naphthas into gasolines with octane ratings in excess of 100-octane F-1 clear. This catalytic reforming process offers refiners practical approaches to higher octanes at relatively low investment.

High-Octane Alternatives with ISO-PLUS HOUDRIFORMING

ISO-PLUS Aromatics Extraction Combinations

1. Iso-Plus Houdriforming with separate Houdriforming of paraffinic raffinate

2. Iso-Plus Houdriforming with recycling of paraffinic raffinate

Variations of the Iso-Plus Process employing aromatics extraction have produced yields of 100-octane gasoline, F-1 clear, of up to 91% of naphtha charge. Slight changes in operation permit refiners to further increase gasoline product octane.

ISO-PLUS Thermal Processing

3. Iso-Plus Houdriforming with thermal reforming of Houdriformate

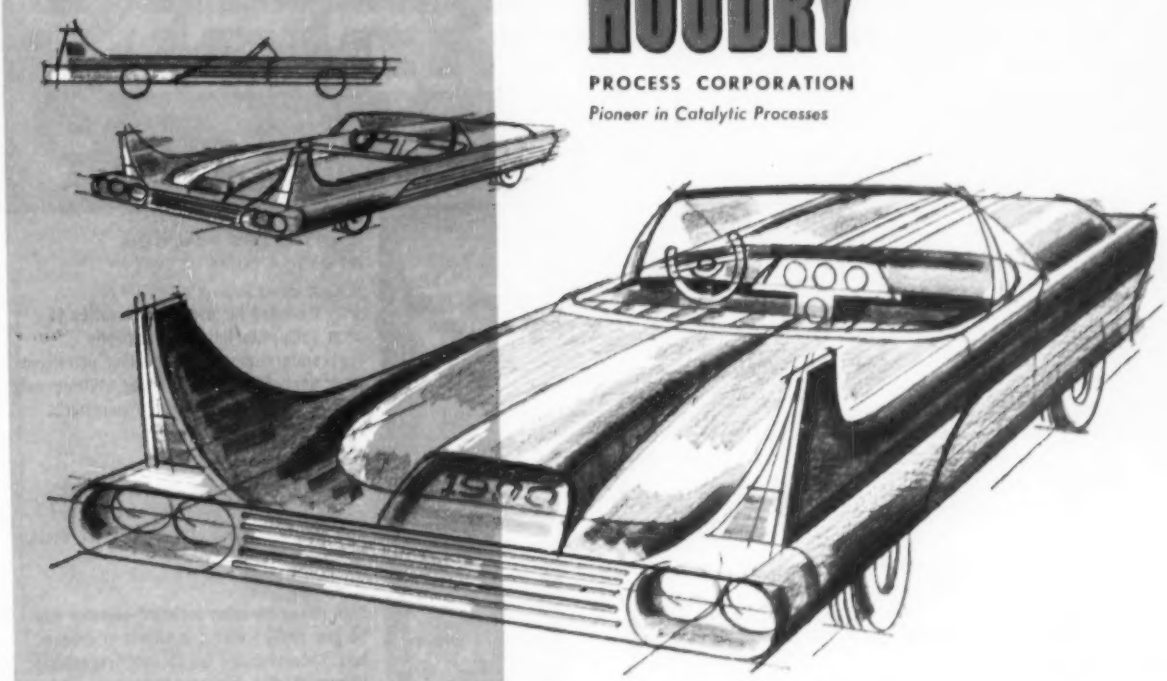
With thermal reforming as the supplementary process, Iso-Plus processing yields 80% to 90% of reformed gasoline, depending upon the desired octane rating of the final product. This operating scheme is especially attractive to refiners with available thermal reforming equipment.

For further information, write to Houdry Process Corporation, 1528 Walnut Street, Philadelphia 2, Pa.

HOUDRY

PROCESS CORPORATION

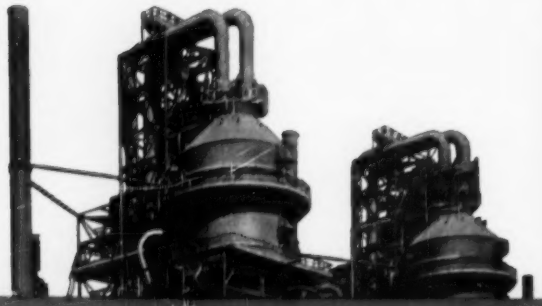
Pioneer in Catalytic Processes



For more data on advertised products, use Readers' Service Cards, last page.

There is a specific A. P. Green Castable for every refractory application in the Petroleum Field. Methods of installation, including troweling, pouring, and "gun" application vary with the particular characteristics of the job. Each A. P. Green castable refractory is specifically designed to provide the required properties of insulation, strength, abrasion resistance and refractoriness for high efficiency operation.

For detailed information and recommendations write the Engineering Department of the A. P. Green Fire Brick Company . . . or call your local A. P. Green distributor.



KAST-SET
A. P. Green KAST-SET is a rapid setting, high strength refractory castable. Mixed with water, it takes on a hydraulic bond without the application of heat. KAST-SET will not shrink, has excellent resistance to abrasion, and is ideally suited for monolithic linings. It may be used at temperatures up to 2700°F.

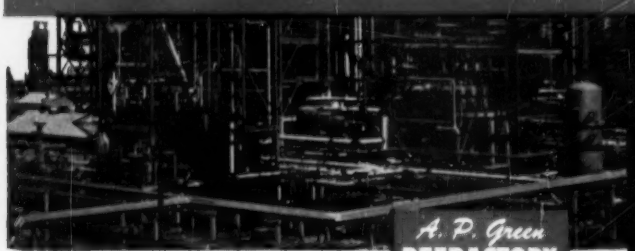
KAST-O-LITE
A lightweight, insulating castable refractory recommended for temperatures up to 2500°F. It is used for complete monolithic linings in all types of oil stills and heaters, tar stills, air heaters, heat treating furnaces, flues and stacks, and for furnace hearth insulation.

CASTABLE INSULATION NO. 20
A hydraulic-setting castable for temperatures up to 2000°F. Recommended for complete monolithic linings and lightweight panel construction in oil stills and heaters.

CASTABLE BLOCK MIX
A hydraulic-setting castable insulation for temperatures up to 1600°F. CASTABLE BLOCK MIX combines the advantages of a castable material with low conductivity and light weight.

A.P. GREEN

HIGH QUALITY REFRACTORY AND INSULATING CASTABLES ASSURE HIGH EFFICIENCY OPERATION OF PETROLEUM EQUIPMENT



Esso Standard Oil Company's fluid catalytic cracking units at the Baton Rouge Refinery where A. P. Green products are in use.

A. P. Green REFRACTORY PRODUCTS

CASTABLES FOR GUN APPLICATION

SK-7 and KS-4
were designed for use in combination to form composite linings in catalytic regenerators, reactors, and other petroleum equipment. Frequently a lining utilizing only SK-7 or KS-4 will fulfill the requirements of the job.

SK-7
Gun application of SK-7 produces a lightweight lining with excellent strength and insulating efficiency. Ideal lining for ducts, flues and breechings.

KS-4
This strong abrasion resistant castable can be gun applied with a minimum of rebound loss. Recommended for catalytic regenerator linings, stack linings, bubble towers, and duct linings exposed to abrasion or corrosion.

A. P. GREEN FIRE BRICK COMPANY
Mexico, Missouri, U. S. A.

PLANTS:
Mexico, Mo.—Woodbridge, N. J.—Sulphur Springs, Texas

IN CANADA:
A. P. Green Fire Brick Company, Ltd.—Toronto 15, Ontario

DISTRIBUTORS IN THE PRINCIPAL CITIES OF THE WORLD

One man in this midget fire truck puts out the fire. Rockwood equipment makes it possible!

"Mighty Mite" puts out fire in 45 seconds

"Mighty Mite" is a swift fire fighter!

It was just a test, but the fire was real. Fuel in a pit under the tank car was set on fire. Fuel poured on top of the car from pipes was also ignited. The blaze was given a minute's start.

"Mighty Mite", loaded with Rockwood fire fighting equipment, went into action. The blaze was choked off in 45 seconds by Rockwood WaterFOG from Rockwood's Remote Manual Control Turret!

Rockwood equipment makes the small truck a big fire fighter. The Turret Nozzle does many jobs—discharges solid water stream, WaterFOG, FogFOAM, solid FOAM stream, "Wet" solid water stream, and "Wet" WaterFOG!

For complete details on this powerful Rockwood equipment send coupon below.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

Distributors in all principal cities

"Mighty Mite's" equipment includes: 4 stage centrifugal pump, 200-gallon booster tank, Rockwood Dual Suction Proportioning System for FOAM and "Wet", Rockwood Remote Manual Control Turret controlled from within the cab, Rockwood Ground Sweep Nozzles, Rockwood Remote Control Ball Valves, 2 hose reels with 200 feet of high pressure hose with new Rockwood High Pressure Handline Nozzle on each reel.

ROCKWOOD SPRINKLER COMPANY
Portable Fire Protection Division
1602 Harlow Street
Worcester 5, Mass.

Please send me your illustrated booklet on Rockwood fire fighting products.

Name.....

Title.....

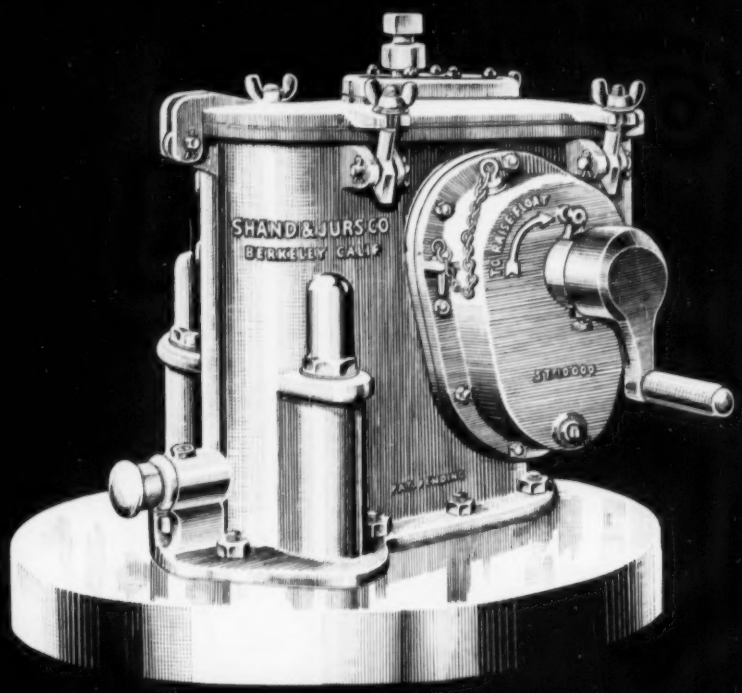
Company.....

Street.....*City*.....

Zone.....*State*.....

For more data on advertised products, use Readers' Service Cards, last page.

Higher and Consistent Accuracy in Marine Tank Gaging—



The new S. & J. Marine Tank Gage, Model ST-10,000, shown above, was designed to permit gaging operations and "topping off" without the necessity of opening hatches in the compartment being filled. This feature helps to maintain SAFE and GAS-FREE conditions on deck, and at the same time affords a more accurate means of determining depth of liquid than has heretofore been used.

S. & J. engineers eliminated the conventional counterweight and accompanying housing, by the use of a new spring, which exerts a constant force, no matter how far below the gage head the float may be riding, or how much tape may be hanging free above the float. This new gage provides consistently higher accuracy, improved visability of reading tape, an adjustable tape reading pointer, and corrosion resistant Teflon bearings throughout. Ship builders and oil tanker operators are invited to inquire for drawings and full details.

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REPRESENTATIVES:
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CARACAS: Sinclair Spence, C.A., Edificio Galipan
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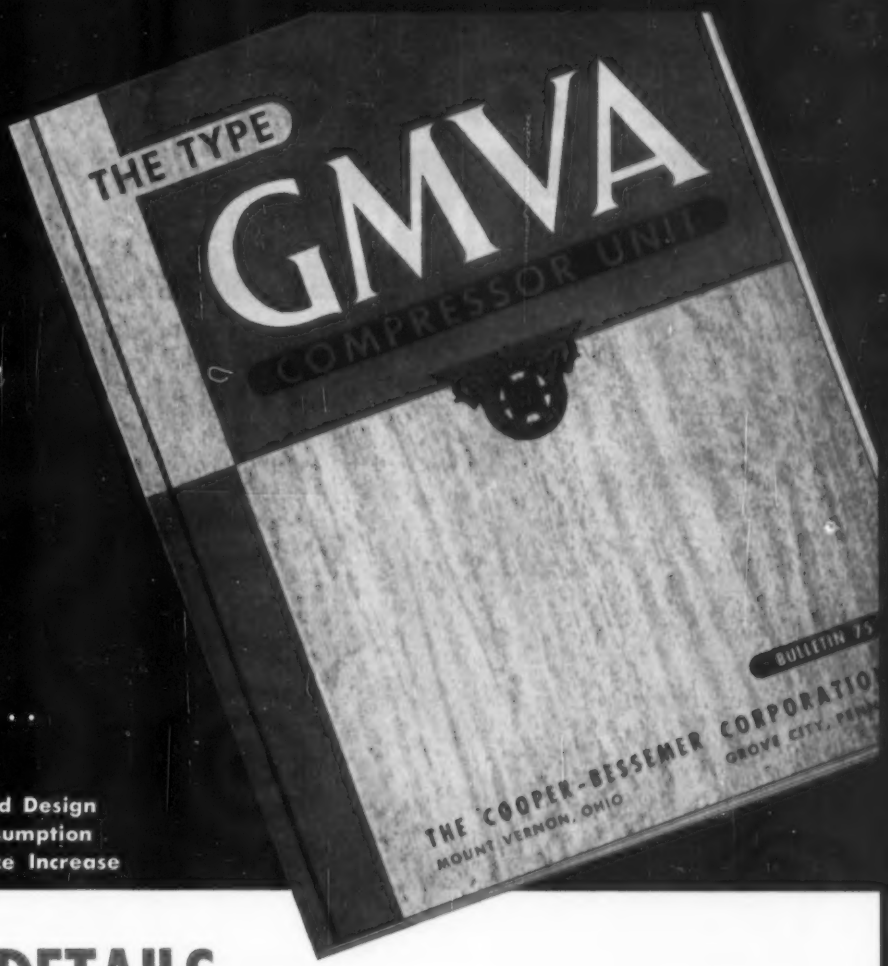
New Economy with the new

GMVA

compressor . . .

- Improvements on an Accepted Design
- 10% Reduction in Fuel Consumption
- Added Horsepower, No Space Increase



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Now, Cooper-Bessemer offers Bulletin 75 as your complete guide to the new GMVA gas engine-driven compressor. Taking the many desirable features of the accepted and industry-proven GMV . . . . plus *big* improvements in engine design and construction . . . . Cooper-Bessemer presents the GMVA bringing *even greater* economy and dependability to the 540-1350 horsepower range.

In this 22-page Bulletin you will find information on such subjects as: V-angle design advantages, streamlined scavenging and lubrication, cooling systems, automatic controls, double deck compressor valves, engine cut-away drawings and photographs of typical installations.

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THE COOPER-BESSEMER CORPORATION 5
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Please send me a copy of Bulletin 75 on the new GMVA compressor unit.

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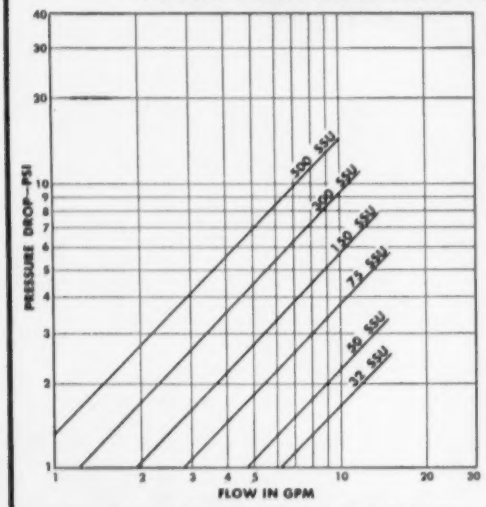
DESIGN AND APPLICATION NOTES ON

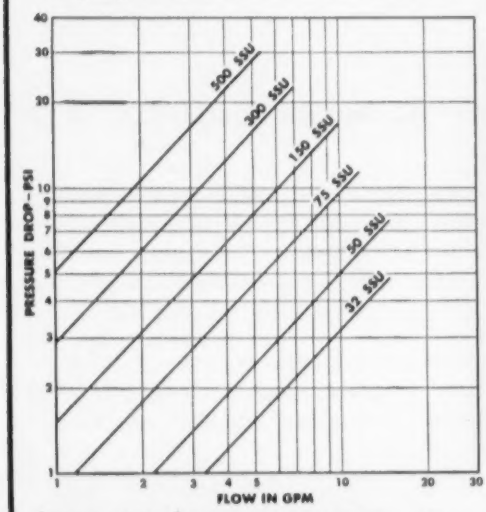
Cuno's new Poro-Klean Filter

TYPICAL PORO-KLEAN FLOW DATA



CYLINDRICAL TYPE

FLOW DATA FOR TYPICAL CYLINDRICAL-TYPE, coarse-grade, PORO-KLEAN filter element, fluid viscosity as parameter. Filtration to 15 microns.



CELL TYPE

FLOW DATA FOR TYPICAL CELL-TYPE, medium-grade, PORO-KLEAN filter element, fluid viscosity as parameter. Filtration to 5 microns.

Precision 3-to-30 micron filter for high temperature and high pressure

PORO-KLEAN, Cuno's new porous stainless steel filter material, now offers the chemical, petrochemical, nuclear, and process industries true micronic filtration for temperatures to 900°F and differential pressures to 2000 psi.

Standard in 316 stainless steel, with low carbon content (0.03 to 0.05% max.), PORO-KLEAN is an ideal filter material for use in applications requiring corrosion resistance, high strength (ultimate tensile strength: 25,000 psi), high resistance to hydraulic shock, or positive freedom from fluid contamination.

Typical PORO-KLEAN applications, already in use in the chemical and process industries, are listed below. Approximate flow-rate curves for typical cell and cylindrical standard elements are shown at left (for exact data, see your Cuno representative).

TYPICAL PORO-KLEAN APPLICATIONS

TO REMOVE:

- Resin and airborne contamination from demineralized water
- Fixed-bed catalyst fines from petroleum products
- Over-cooked gels from polymers
- Radioactive contamination from light and heavy water
- Fine precoat particles downstream from primary filters
- Contamination and/or catalysts from high-temperature and high-pressure refinery gases
- Metal oxides from molten sodium, sodium-potassium, and bismuth
- Iron oxides from fuels
- Rust from steam
- Foreign matter from pharmaceuticals

TO RECOVER:

- Catalysts from gases and liquids

TO DISPERSE:

- Gases into liquids and other gases

If you have problems like these, let Cuno engineers help you apply PORO-KLEAN to their solution. See your Cuno representative, or write Cuno Engineering Corporation, 33-7 South Vine Street, Meriden, Conn. 5.20

CUNO

ENGINEERED FILTRATION

Removes More Sizes of Solids From More Kinds of Fluids

AUTO-KLEAN (edge type) • MICRO-KLEAN (fibre cartridge) • FLO-KLEAN (wire-wound) • PORO-KLEAN (porous stainless steel)

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RD 150

"...MOST EFFICIENT PLATINUM CATALYST FOR HIGH OCTANE OPERATIONS..."

BAKER'S RD 150 is proving to be the most efficient of all reforming catalysts, *especially* so for high octane operations. Baker's RD 150 assures important yield increases at high octane levels . . . long periods of operation . . . and *regeneration in situ!* The practical advantages offered by RD 150 results in low cost operation.

RD 150 is a joint development of Baker & Company, Inc. and Sinclair Research Laboratories. It is now being used in successful production by such companies as Sinclair, Socony and Pure Oil.

The very extensive facilities for manufacture and refining in modern Baker plants, provide full assurance of prompt deliveries and service.

The complete RD 150 story will be interesting to you. A Baker representative will be glad to give you detailed information, upon request.

BAKER & COMPANY, INC. CATALYSTS

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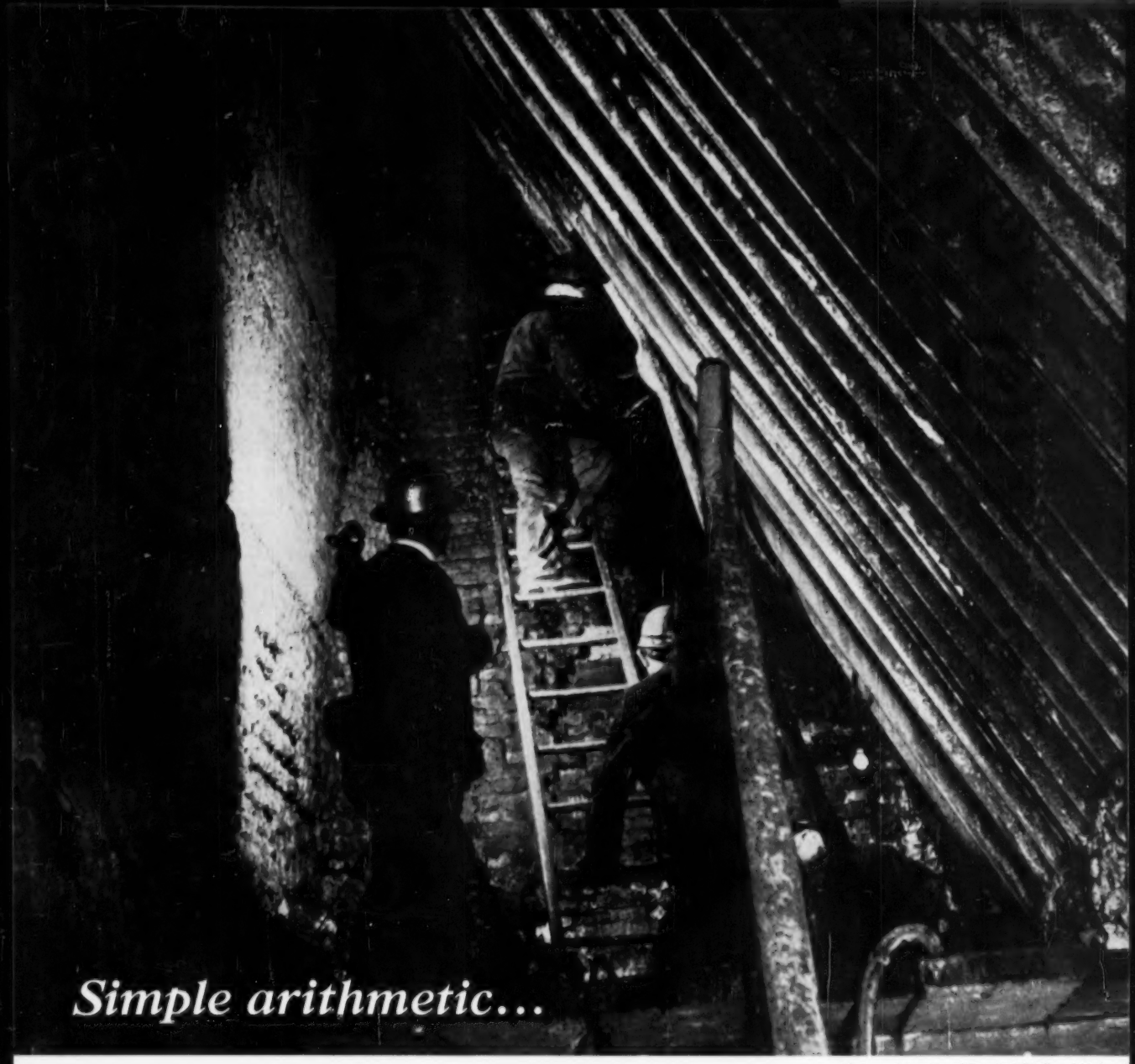


—Photograph courtesy of Standard Oil Co. of N. J.

with Ljungstrom® Air Preheaters, four of your present stills can do the work of five

You'll have far less slag—much less downtime for maintenance—with the Ljungstrom Air Preheater. This unit produces more complete combustion, at higher temperatures, because preheated air mixes more thoroughly with fuel. And in addition, Ljungstrom efficiency makes possible finer process control and advanced furnace designs. Thus, Ljungstrom savings are real and measurable. One still, Ljungstrom equipped, added $58,000 of income annually from higher product quality alone.

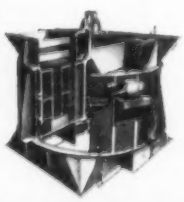
How fast is "WRITE OFF"?

Unusually short. Major savings are gained from higher average octane ratings. And other Ljungstrom advantages—up to 20% fuel savings . . . more economical furnace design, with no need for convection surfaces . . . use of many fuels you used to throw away . . . consistently higher throughput . . . shorter turnaround time—mean that a Ljungstrom is paid out in a very few months.

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits attainable in fuel burning equipment—call or write the Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.



The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

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Gas Processing Plant

REYNOSA, MEXICO

Below the Rio Grande, near Reynosa, in Tamaulipas, Mexico, Petroleos Mexicanos has recently completed this major gas processing project designed to process 300 million cubic feet of natural gas daily gathered from numerous fields within an area of about 400 square miles. About 8,000 barrels per day of fractionated products, including propane, butanes, motor fuel, naphtha and kerosene will be produced.

Engineering design and procurement of equipment was entrusted to Hudson, and the satisfaction of our client is attested by a current contract for a similar but even larger project for Petroleos Mexicanos on the Isthmus of Tehuantepec.

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OIL AND GAS PROCESSING PLANTS

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ENGINEERING CORPORATION

FAIRVIEW STATION • HOUSTON, TEXAS

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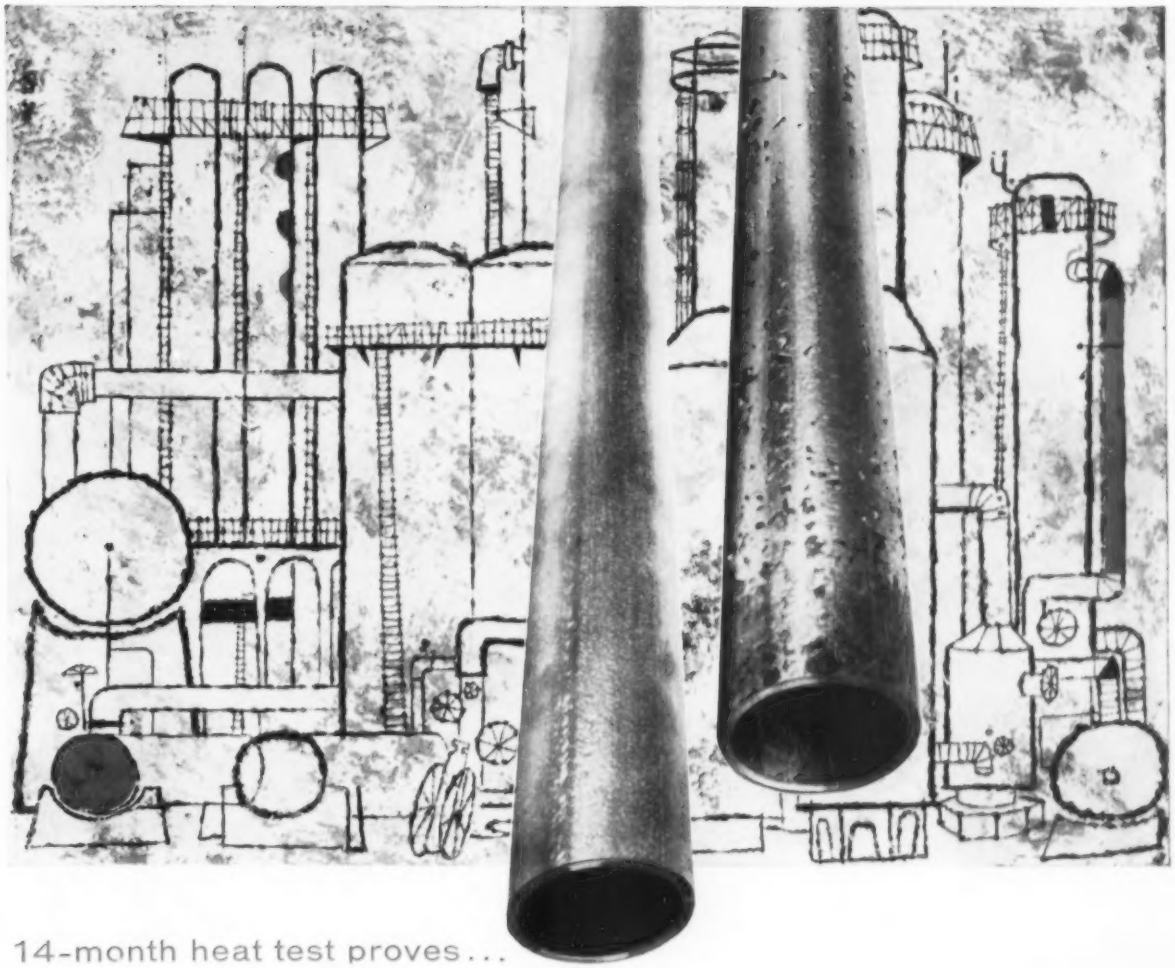

14-month heat test proves . . .

Sili-Kool Aluminum Paint superior to ordinary paint for "hot" surfaces

Exhaustive tests under actual operating conditions dramatically prove Sili-Kool Aluminum Paint's ability to give full protection despite extreme heat and exposure. The two sections of pipe, shown above, were in identical service, carrying hot air (up to 1600°F) in the most unfavorable weather conditions. The pipe on the right was painted with an ordinary heat resistant paint. The pipe on the left was painted with Silicone High Heat Paint pigmented with the best silicone and aluminum pigments. After fourteen months of constant high heat service, the pipe treated with Sili-Kool Aluminum Paint is entirely free from oxidation, corrosion and rust while the other pipe is dangerously corroded. Sili-Kool High Heat Paint, pigmented with ALCOA® Aluminum, is manufactured by the C. H. DRAGERT COMPANY, INC., Dallas, Texas.

ALCOA does not make paint, but ALCOA Aluminum Pigments are used in more aluminum paints than any other brand. Special formulas have been developed by your paint manufacturer to solve individual problems. Paints made to these formulas actually cost less, last longer, give utmost protection against heat, cold, sun, rain, smoke and fumes.

Write today for our two FREE booklets, *Painting With Aluminum* and *Aluminum Asphalt Roof Coatings Make Time Stand Still.* They contain valuable, up-to-date information on all types of aluminum paint and aluminum asphalt coatings. Use the coupon.

THE ALCOA HOUR
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ALTERNATE SUNDAY EVENINGS

PIGMENTED WITH
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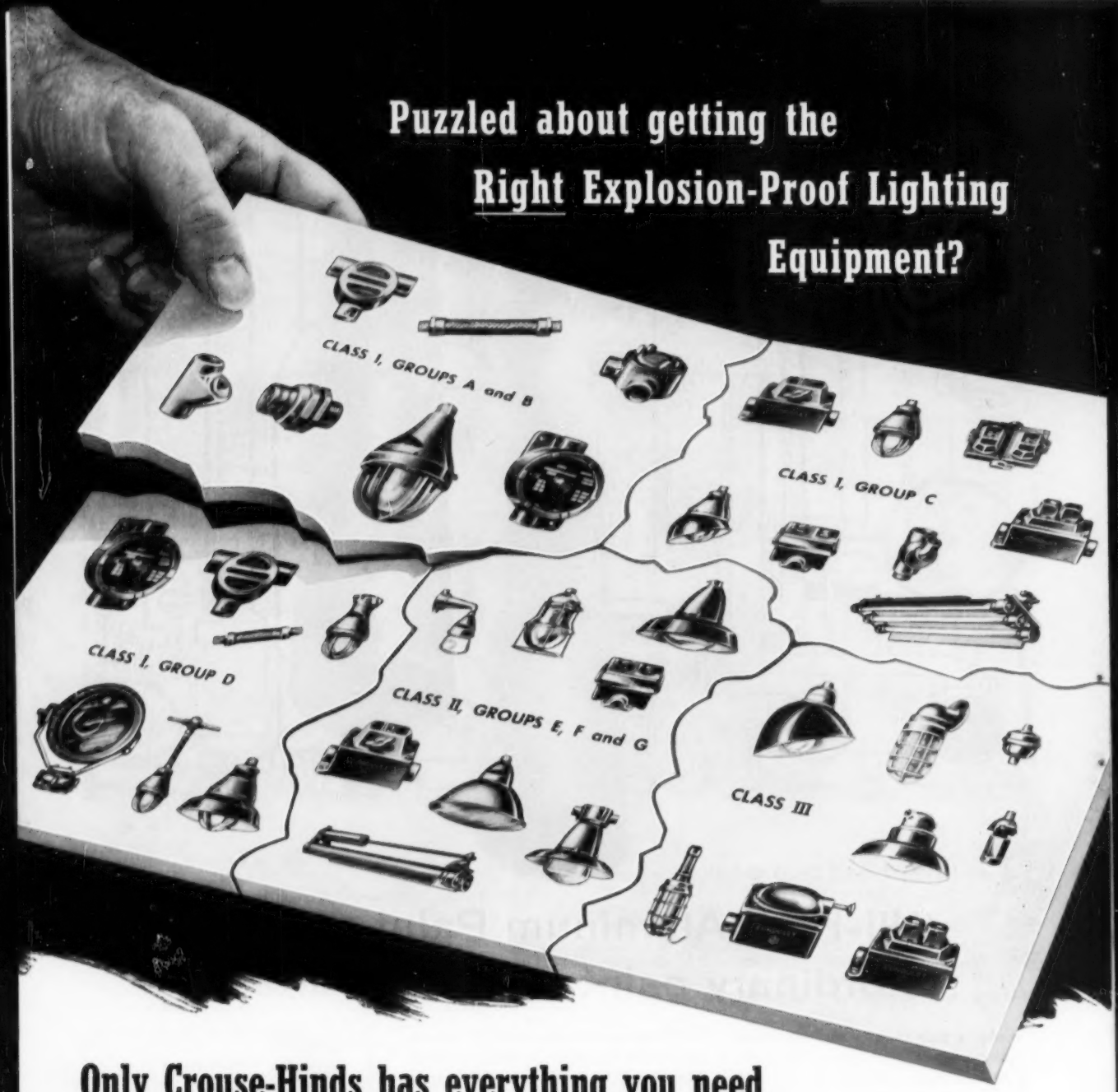
Puzzled about getting the Right Explosion-Proof Lighting Equipment?



Only Crouse-Hinds has everything you need

...in every class ...in every group!

For *complete* protection when making lighting installations in hazardous locations you need more than explosion-proof or dust-tight lighting fixtures. You also need UL-listed explosion-proof switches, junctions, fixture supports, unions and seals.

Crouse-Hinds now offers a broad selection of Condulet* explosion-proof lighting equipment for Class I, Groups A and B locations. In fact, you can specify complete Crouse-Hinds explosion-proof lighting installations, all UL-listed, *no matter what class or group of Article 500 of the National Electrical Code is involved.*

The same holds true for the entire Crouse-Hinds Condulet line of more than 15,000 conventional and explosion-proof items. With the broadest line in the field, Crouse-Hinds recommends *exactly* what you need . . . and *only* what you need.

A nearby Crouse-Hinds distributor will be glad to discuss your explosion-proofing problems and make recommendations without obligation.

A NATIONWIDE DISTRIBUTION exclusively through ELECTRICAL DISTRIBUTORS

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Tough Expansion Joint Problem?

Put the Badger Man on the Spot!

Complex expansion joint problems are *best* analyzed at only one place: your office or plant site. It's there alone that *all* essential data about your proposed installation is available.

And it's there — *on the spot* — that the Badger Man is ready to apply his unique abilities. He is a trained engineer *and* he brings to your problem the background of the world's most experienced manufacturer of expansion joints.*

Next time you are confronted with a complicated piping layout, severe operating conditions, unusual size and shape requirements — *any* complex expansion joint problem — put the Badger Man on the spot! His services are as close as your telephone.

COMING SOON — Badger Service-Rated Expansion Joints. Incorporate revolutionary new features developed during three years of intensive research and testing. Watch for this important announcement.

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BADGER EXPANSION JOINTS

BADGER MANUFACTURING COMPANY

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*Badger has been solving tough expansion joint problems for 50 years — a record unmatched by any other firm.

Buyers of Any Process Equipment Reap Benefits from M. W. Kellogg's

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As a leader in the design and fabrication of petroleum and petrochemical process equipment, The M. W. Kellogg Company assumes many extra curricular responsibilities which eventually benefit not only its customers but the process industries in general. One of these responsibilities is Kellogg's participation in technical committees of professional societies and associations, particularly at subcommittee working levels.

At present, M. W. Kellogg's engineers, metallurgists and others give a considerable part of their time to over seventy such activities . . . ranging from boiler and pressure piping codes to welding practices and radiographic testing techniques. Many of today's accepted design concepts were introduced to the engineering profession by Kellogg committee men.

The M. W. Kellogg Company is privileged to contribute increasingly to the important work of technical and engineering societies, associations, and related groups. The practical application of the knowledge imparted and gained is another plus which goes into Kellogg's "built-in engineer" approach to process equipment design and fabrication. A typical example is a paper prepared by M. W. Kellogg engineers, "Collection and Correlation of High Temperature Hydrogen Sulfide Corrosion Data," and presented at a recent meeting of the National Association of Corrosion Engineers. *Write for your copy.*

Fabricated Products Division

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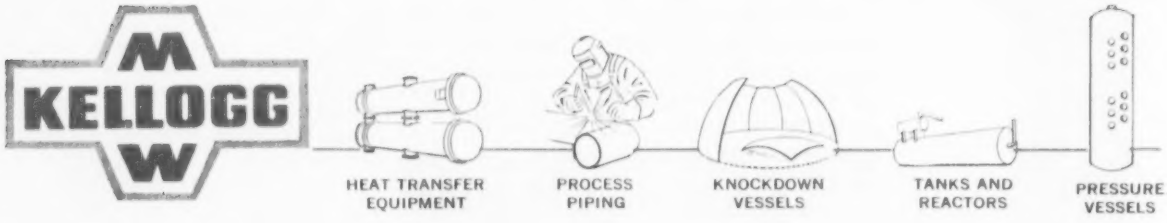

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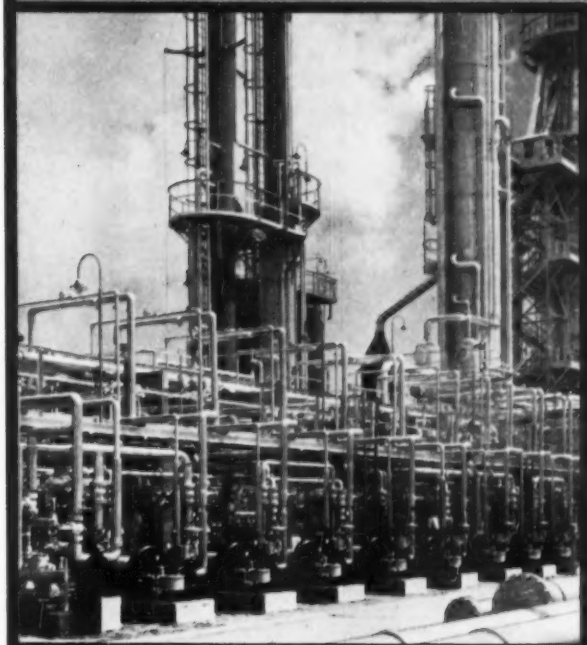
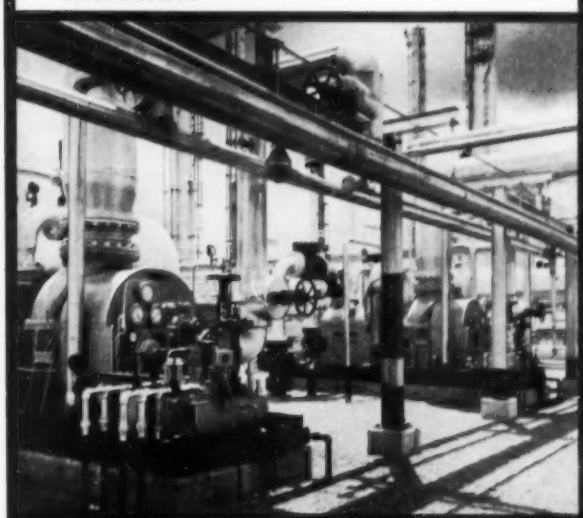
for 50 years — a record unmatched by any other firm.

Which Steam Turbine For Your Job?



(Above) Seventy-five Elliott turbines, sized from 8 to 224 hp, drive pumps and fans throughout this Southwestern refinery.

(Below) Two Elliott 2100-hp, 4450-rpm, multistage single-valve turbines driving lean oil pumps in a new gasoline plant in Texas. Turbines have variable-speed governors and uncontrolled extraction.



Close-up of the rugged and reliable Elliott Type JR turbine driving a small pump. Sturdy design and minimum first cost make this a popular choice for low hp requirements (up to 45 hp, 4000 rpm).

ELLIOTT TURBINES, from the smallest single-stage, to large multistage types, are busy serving refineries everywhere — standard single-stage turbines for most jobs, multistage turbines for larger sizes where economy is important, the JR for small sizes.

Your local Elliott Field Engineer can help you pick the type for your job. Check with him or write Elliott Company, Steam Turbine Division, Jeannette, Pa.

ELLIOTT Company

STEAM TURBINES • MOTORS • GENERATORS • DEAERATING HEATERS • EJECTORS • CONDENSERS
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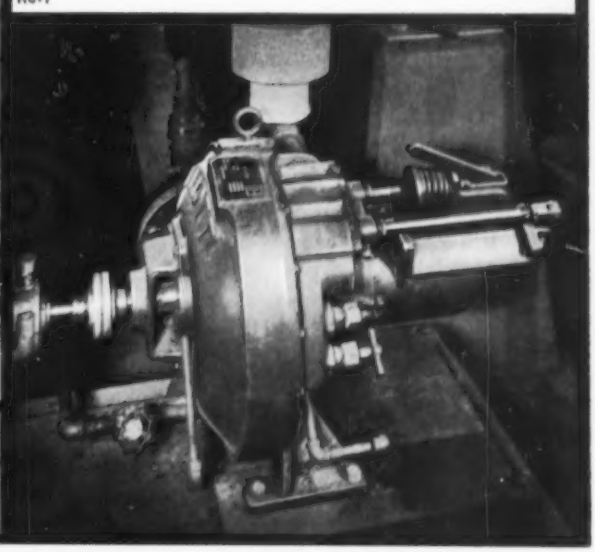
HG-1



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how much does heater downtime cost?

A 36,000 B/D petroleum refining unit using a 100 million Btu heater upgrades the value of its crude charge roughly $25,000 per stream day. If the heater comes down for any reason only 10 days a year, a loss of a quarter million dollars is chalked up. A gain of 30 operating days in the year can mean a realization of 10% on capital investment which, in a multi-million dollar plant, is a considerable sum.

Downtime is expensive. The purchaser of a heater must as a result look beyond his initial cost to the long pull. For the long pull, Lummus oil heaters have consistently exhibited great durability while operating efficiently and with an absolute minimum of days lost to maintenance work.

The major refiners prefer Lummus heaters for this reason. In the last 25 years, the dollar value of Lummus furnaces purchased has exceeded that of any other company in the world. So—when you consider a new refinery or a new unit—assure good operation and maximum profit throughout the life of your plant.

Consult with us on design, engineering and construction of your heater installation.

The Lummus Company, Oil Heater Division, 385 Madison Avenue, New York 17, N. Y. Branch offices in Chicago, Houston, Montreal, London, Paris, The Hague, Caracas.

LUMMUS

OIL HEATER DIVISION

B&W HOLLOW FORGINGS ARE SUPPLIED IN THE FOLLOWING STANDARD MATERIALS

CARBON STEELS

ASTM A 106 Grade A
ASTM A 106 Grade B
ASTM A 106 Grade C

Analyses such as SAE or AISI carbon steel will be considered if quantities are sufficient.

INTERMEDIATE CROLOYS
ASTM SPEC. A 335

Carbon Moly	P 1
Carbon Moly High Silicon	P 15
Croloy ½	P 2
Croloy 1	P 12
Croloy 1¼	P 11
Croloy 1¾	P 3
Croloy 2	P 3b
Croloy 2¼	P 22
Croloy 3M	P 21
Croloy 5	P 5
Croloy 5 Si	P 5b
Croloy 7	P7
Croloy 9-M	P 9

ASTM Spec. A 335 has superseded and replaced ASTM Specs. A 158, A 206, A 280 and A 315.

This list includes all grades of A 335 except grade P 5c, which we do not make.

B&W Croloys, 2½, 3, 5M, 7M, and 9, are not included in A 335. We will supply these additional alloys in accordance with A 335, except for chemistry, upon request.

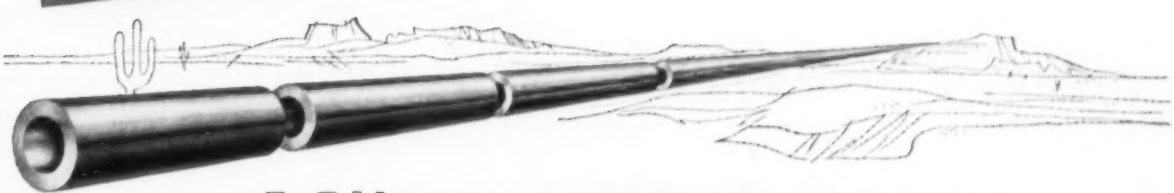
STAINLESS STEELS
ASTM SPEC. A 312

Croloy 18-8	TP 304
Croloy 18-8 Ti	TP 321
Croloy 18-8 Cb-Ta	TP 347 (Cb-Ta)
Croloy 18-8 Cb	TP 347 (Cb)
Croloy 16-13-3	TP 316

These grades will also be made to ASTM specification A 376 excluding "special inspection" requirements.

Other grades of Stainless Steel listed under A 312 are TP 309, TP 310, TP 317. These grades are presently not offered as standard, but will be considered on request.

Sold in just one year!



Miles of B&W Hollow Forgings

. . . in a range of analyses with sizes up to 35" O.D.

Many miles of B&W Hollow Forgings, of all sizes and analyses, were sold for use in the power, petroleum and chemical industries in 1955. Excellent manufacturing facilities, plus B&W's ability to accept orders for both large and small quantities for definite deliveries, are some of the factors that have resulted in this widespread preference for B&W Hollow Forgings.

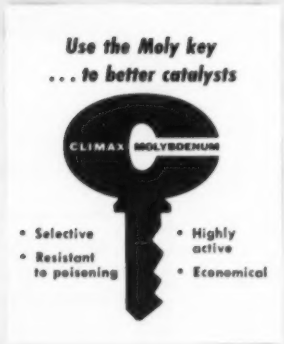
For the complete B&W Hollow Forgings story, send for new Bulletin S-16B. The Babcock & Wilcox Company, Process Equipment Department, Barberton, Ohio.

BABCOCK & WILCOX

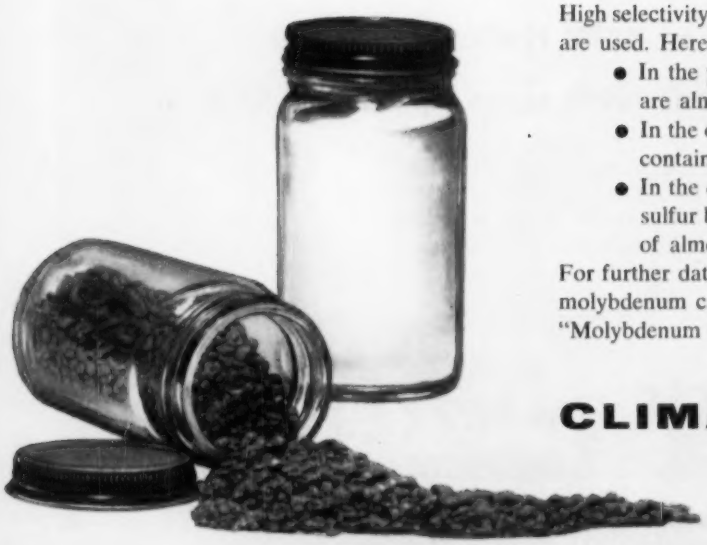
BOILER DIVISION

S-454-A

For more data on advertised products, use Readers' Service Cards, last page.



Moly catalysts are selective



High selectivity is provided in reactions where molybdenum catalysts are used. Here are three examples:

- In the production of formaldehyde from methanol, yields are almost quantitative.
- In the oxidation of aliphatics to maleic anhydride, the product contains no by-product maleic or fumaric acid.
- In the desulfurization of petroleum stocks, the carbon to sulfur bond is selectively hydrogenated with recoveries of almost 100%.

For further data on these reactions as well as many others using molybdenum catalysts, write Dept. 25 for our bulletin "Molybdenum Catalysts for Industrial Processes."

CLIMAX MOLYBDENUM

500 Fifth Avenue, New York 36, N. Y.

dbpc® antioxidant . . . a quality Koppers Chemical

Can these eleven advantages improve your gasoline and save you $1,000,000?

HOW ONE REFINERY SAVED $1,007,000

Inhibition of light cracked stock:	CASE 1 Phenylene-diamine	CASE 2 dbpc
Cost for treating 9000 B/D of 250-330°F intermediate fraction, $/day:		
Unisol treating, operating cost	—	1,130
Loss to Unisol treating	—	nil
Acid treating and redistillation, operating cost	1,740	—
Loss to acid sludge (2% at $4.50/bbl.)	810	—
Doctor treating, operating cost	530	—
Loss to Doctor treating (2% at $4.50/bbl.)	810	—
Total	3,890	1,130

Saved with dbpc on production of
45,000 bbl./day: dollars/day 2,760
45,000 bbl./day: dollars/year 1,007,000

The cost of inhibition was practically identical for the two cases cited above. Let our representative give you specific money-saving details relating to your operations. Koppers Company, Inc., Chemical Division, Department PR76, Pittsburgh 19, Pennsylvania.

1. **dbpc** (di-tertiary - butyl - para - cresol) gives the best protection against gum formation in gasoline, when compared under conditions of use with today's leading antioxidants.
2. **dbpc** reduces treating costs.
3. **dbpc** keeps automotive power systems clean because it keeps unstable gasoline constituents from depositing in carburetors, manifold piping, and intake ports.
4. **dbpc** doesn't induce "tank sweetening."
5. **dbpc** is a more effective oxidation inhibitor because it can be added early in the refining process and is not extracted by sweetening, caustic washing, clay treating, or water washing.
6. **dbpc** is not extracted by aqueous corrosion inhibitors, nor by acidic water solutions sometimes found in tank bottoms and pipelines.
7. **dbpc,** being inert, does not cause gasoline to darken or change color.
8. **dbpc** does not require special handling precautions.
9. **dbpc** retains more of its antioxidant properties than other types, in the presence of iron, copper, brass, and other copper-bearing metal alloys.
10. **dbpc** provides excellent stabilization of aviation gasolines and tetraethyllead fluids.
11. **dbpc** is safer and easier to handle than other antioxidants, because it is relatively non-toxic and non-irritating.

KOPPERS

KOPPERS CHEMICALS

SALES OFFICES: NEW YORK · BOSTON · PHILADELPHIA · ATLANTA
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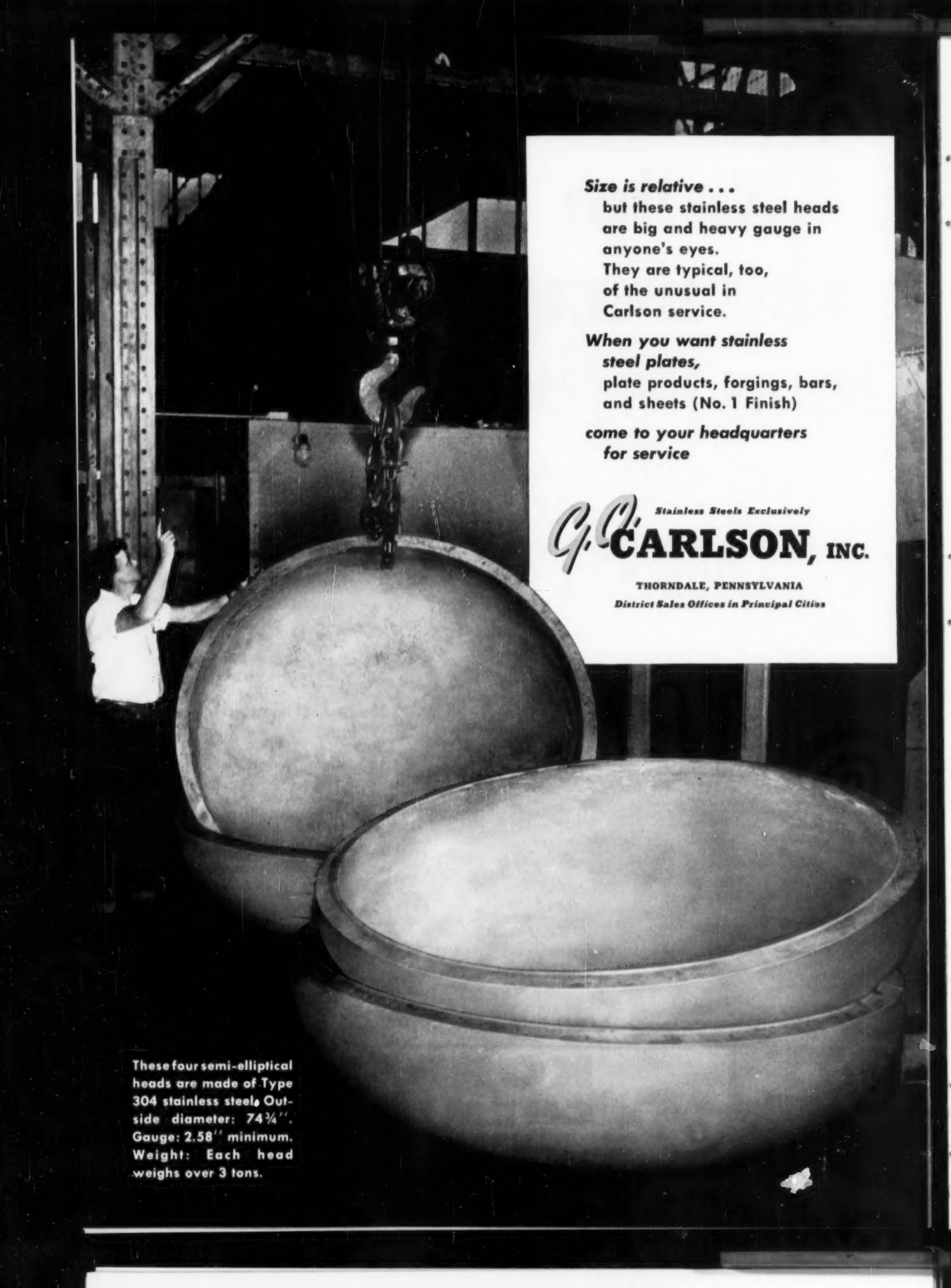
For more data on advertised products, use Readers' Service Cards, last page.



Size is relative . . .
but these stainless steel heads
are big and heavy gauge in
anyone's eyes.
They are typical, too,
of the unusual in
Carlson service.

When you want stainless steel plates,
plate products, forgings, bars,
and sheets (No. 1 Finish)

come to your headquarters for service

Stainless Steels Exclusively

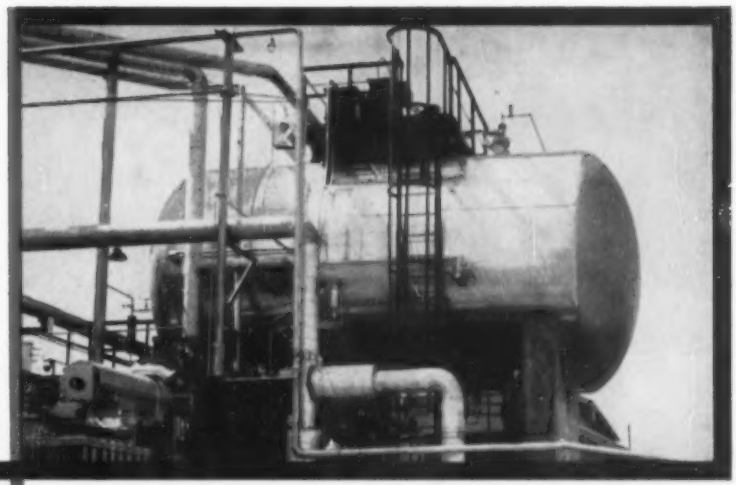
C. O. CARLSON, INC.

THORNDALE, PENNSYLVANIA

District Sales Offices in Principal Cities

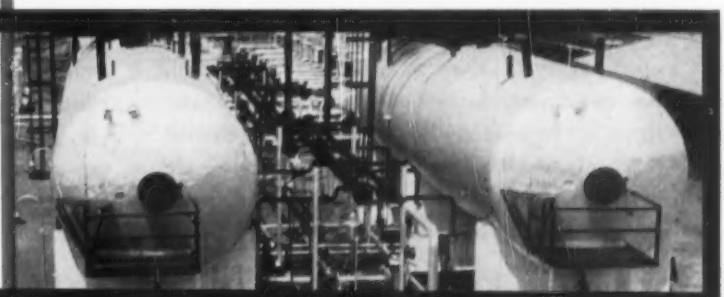
These four semi-elliptical heads are made of Type 304 stainless steel. Outside diameter: 74¾". Gauge: 2.58" minimum. Weight: Each head weighs over 3 tons.

HOW TO SOLVE A SALT PROBLEM



+	ADD	A PETRECO Electric Desalter to your crude processing equipment. It will
−	SUBTRACT	the salts, fines and other impurities from your crude charge, enabling you to
÷	DIVIDE	your lost time on stream and maintenance costs by 2 or 3 and
×	MULTIPLY	your total unit throughput and refining profits.

Petreco pioneered electric desalting and has originated the major developments since its beginning. No other method offers a superior technical service staff, backed by so many years of desalting experience. Petreco electric desalting is used by more refiners than any other method.



SPECIALIZED ELECTRIC PETROLEUM TREATING

Desalting • Dehydrating • Caustic Washing • Acid Contacting • Doctor Treating • Sweetening • Naphthenic Acid Removal • Sediment Removal

FOR COMPLETE INFORMATION, WRITE OR CALL

PETRECO

A DIVISION OF PETROLITE CORPORATION

3202 S. Wayside Drive, Houston 1, Texas
1390 East Burnett St., Long Beach 7, California

DS 6-4

For more data on advertised products, use Readers' Service Cards, last page.

HYDROCRANE'S WORKING BOOM HOIST
Speeds Refinery Digging, Lifting Jobs

With the Hydrocrane, *any* boom angle is a working position because the boom is raised or lowered dozens of times a day as part of the crane's regular operating cycle. Even with full load suspended, you can raise or lower boom, and swing or telescope *at the same time,* with the precise control that only the Hydrocrane offers. It's just one of the many unique, time-saving features that make the Bucyrus-Erie Hydrocrane the ideal refinery tool.

You also gain many advantages working in confined areas. The Hydrocrane's working boom hoist, together with the line hoist, lifts the load over stockpiles and ground obstructions, under overhead steam or other pipe lines as it swings to the spot . . . and places it in position positively and quickly. Hydrocrane's rugged outriggers, which permit conventional motor truck mounting, give you an unusual combination of high capacity and top mobility. Extremely short tail swing lets you put the crane in the tightest spots.

Hydrocranes are now available in two sizes — the 5-ton H-3 and the 9-ton H-5. See one in action soon — arrange for a demonstration with your Bucyrus-Erie distributor. 135H56

BUCYRUS • ERIE COMPANY • South Milwaukee, Wisconsin

For more data on advertised products, use Readers' Service Cards, last page.

Red-hot recipe for tougher tank cars

Typical DURADOME—designed for formaldehyde service

WHEN heavy-gauge steel is formed and welded into a tank car tank . . . certain internal stresses develop which tend to weaken the metal. That is why ACF tanks are "popped into the oven" to relieve these stresses.

Each tank is scientifically heated under controlled conditions. This results in a tank of uniform strength which is ready to resist the forces of load and impact which occur during transportation.

When you're looking for the toughest tank cars ever built, look to Shippers'. We are the exclusive sales agent of ACF-DURADOME tank cars for industry. You'll find a nationwide network of Shippers' Car Line offices and repair shops ready to serve your transportation needs.

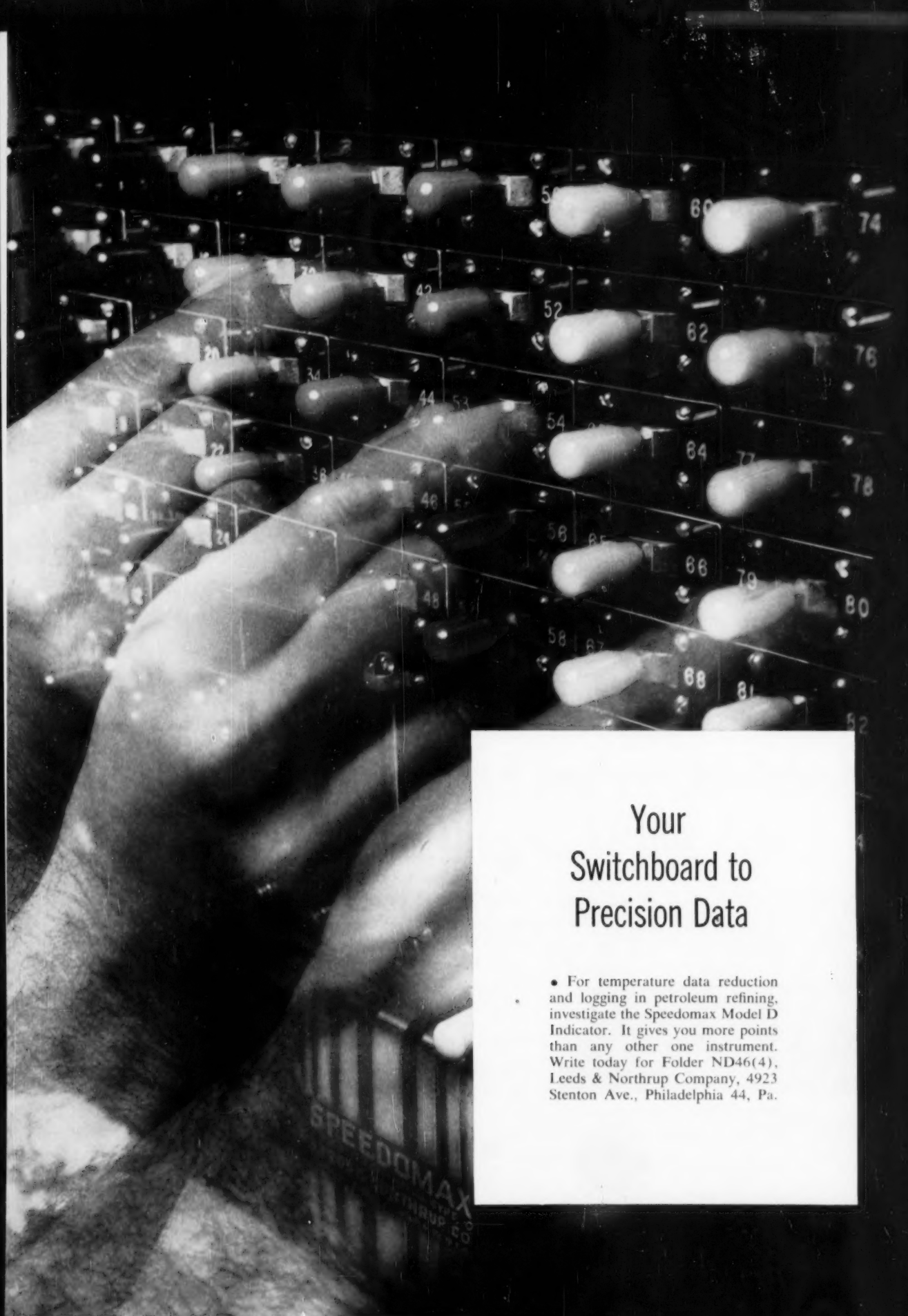
Whatever your tank car requirements may be, better talk to Shippers' . . . and get the benefits of *modern* tank car service!

SHIPPERS' CAR LINE

Division of ACF INDUSTRIES, Incorporated

30 Church Street, New York 7, N. Y.

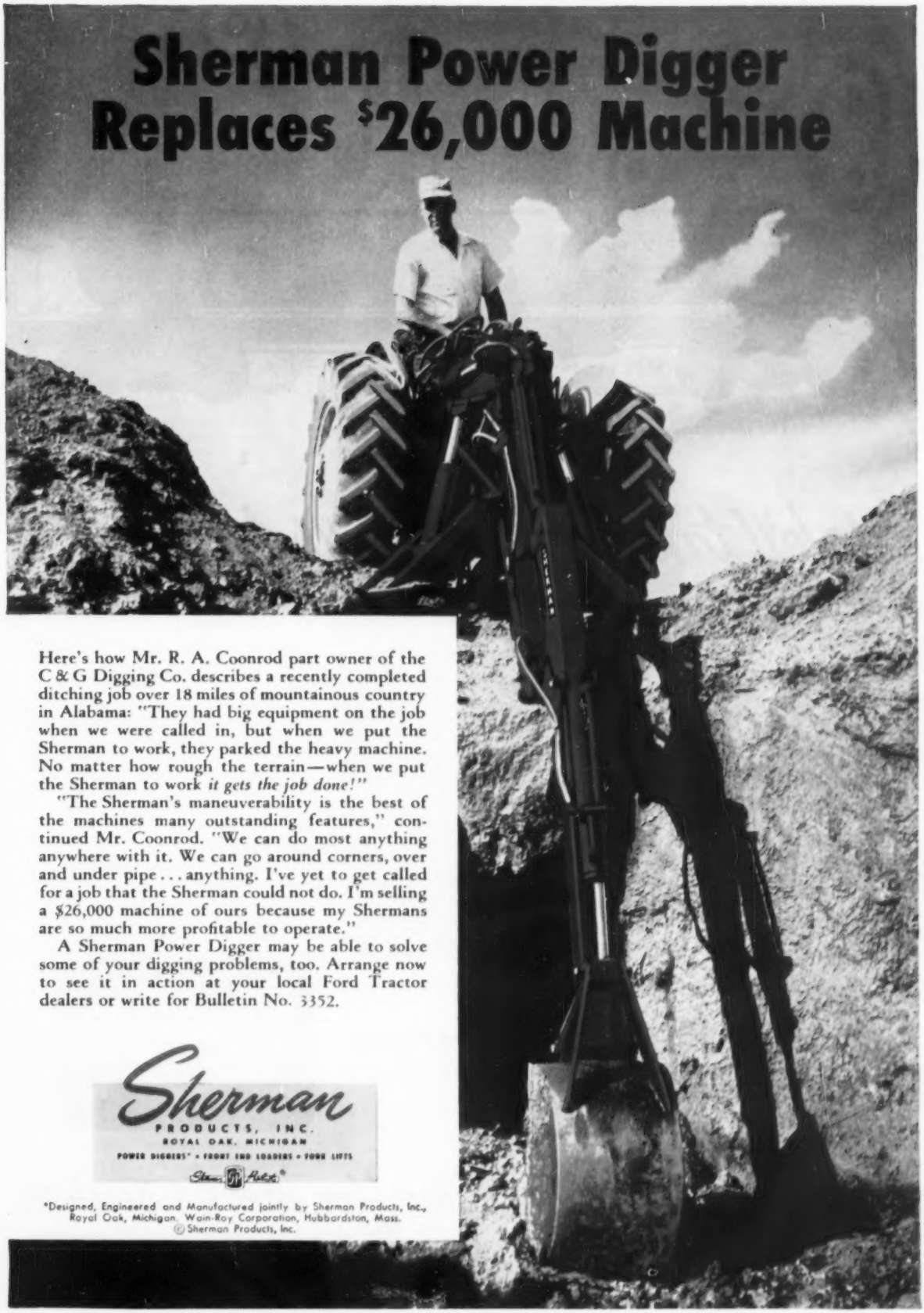
CHICAGO, ILL. • HOUSTON, TEX. • SAN FRANCISCO, CAL. • MILTON, PA. • EAST ST. LOUIS, ILL. • SMACKOVER, ARK. • TULSA, OKLA. • NORTH KANSAS CITY, MO. • RED HOUSE, W. VA.



Your Switchboard to Precision Data

• For temperature data reduction and logging in petroleum refining, investigate the Speedomax Model D Indicator. It gives you more points than any other one instrument. Write today for Folder ND46(4), Leeds & Northrup Company, 4923 Stenton Ave., Philadelphia 44, Pa.

Sherman Power Digger Replaces $26,000 Machine



Here's how Mr. R. A. Coonrod part owner of the C & G Digging Co. describes a recently completed ditching job over 18 miles of mountainous country in Alabama: "They had big equipment on the job when we were called in, but when we put the Sherman to work, they parked the heavy machine. No matter how rough the terrain—when we put the Sherman to work *it gets the job done!*"

"The Sherman's maneuverability is the best of the machines many outstanding features," continued Mr. Coonrod. "We can do most anything anywhere with it. We can go around corners, over and under pipe . . . anything. I've yet to get called for a job that the Sherman could not do. I'm selling a $26,000 machine of ours because my Shermans are so much more profitable to operate."

A Sherman Power Digger may be able to solve some of your digging problems, too. Arrange now to see it in action at your local Ford Tractor dealers or write for Bulletin No. 3352.

Sherman
PRODUCTS, INC.
ROYAL OAK, MICHIGAN
POWER DIGGERS* • FRONT END LOADERS • FORK LIFTS

*Designed, Engineered and Manufactured jointly by Sherman Products, Inc., Royal Oak, Michigan. Wain-Roy Corporation, Hubbardston, Mass.
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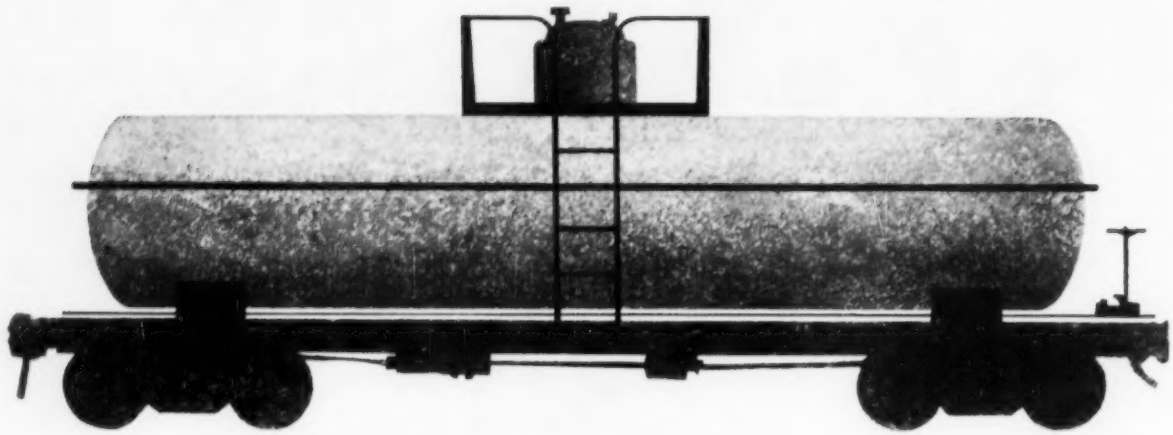
For more data on advertised products, use Readers' Service Cards, last page.



We'll take it...or we'll drink it

Sulfuric Acid sludge is a problem to many...but not to Stauffer!
If you can pour it or pump it or get it in a tank car...
send it to Stauffer. We'll "unsludge" it
and send it back to you... 98% pure H_2SO_4.
If you have no sludge and just need Sulfuric Acid,
we have that, too. Available in tank trucks or tank cars
of 6 to 100 tons capacity and barges of
800 to 1500 tons... wherever and whenever you want it
in unlimited supply of all commercial grades.

STAUFFER CHEMICAL COMPANY
380 Madison Avenue, New York 17, N.Y.
Telephone: OXford 7-0600

Stauffer CHEMICALS SINCE 1885

Stauffer means service

PETROLEUM CHEMICALS DIVISION

NEWS

July ★ One of a Series of Bulletins for the Petroleum Industry ★ 1956

Question Box

1. HOW can you persuade your dealers to try for increased sales volume on the basis of good management practices?

   The article at the right may give you some ideas.

2. HOW can you insure stability of distillate fuel oils?

   See below for answer and other important information concerning effective additives.

3. WHO can help you with your fuel oil stability problems?

   You can read on the next page about one of many Du Pont specialists in this field.

Need continues for additives in all types of fuel oils

The market for fuel oils is becoming more complex as the result of a demand for petroleum products tailored to specific consumer needs.

To accomplish this tailoring job, chemical additives generally offer you the easiest and most economical means . . . particularly where stability and blending compatibility problems are involved. This is true of furnace oils, diesel fuels, and residual fuels.

The various aspects of tailoring these different types of fuel oils to consumer demands through the use of additives were recently discussed in a paper by William deB. Bertolette and John D. Rogers of the Du Pont Petroleum Laboratory, presented before the Western Petroleum Refiners' Association.

Du Pont Fuel Oil Additive No. 2 (FOA-2) is ideally suited for stabilizing these fuel oils because it is an *ashless* polymeric additive. This means that it does not leave a metallic deposit or alter the chemical characteristics of the deposits that are formed.

Stabilizer and dispersant

Du Pont FOA-2 not only stabilizes the fuel to prevent sludge formation, but it also helps to rid dirty systems of any sludge that may have previously formed.

If you would like more information on Du Pont FOA-2 or a copy of the W.P.R.A. paper entitled "Improving Fuel Oils through the Use of Additives," just send your request to any of our sales offices listed on the next page.

Why are some dealers more successful than others?

The latest report — No. 5 in the Du Pont Service Station Operator Survey — reveals many controllable factors bearing on this question.

"Stay open long hours . . . advertise . . . carry a complete line of tires, batteries and accessories!"

These three practices are common to *most* of the stations which are *most* successful. There are, however, many more ingredients of success revealed in Du Pont's Service Station Operator Survey, Report No. 5, just published.

Marketing men in the industry of course are well aware of the factors which make a service station successful.

However, the highly interesting statistics developed through the survey may help them determine the degree to which each factor contributes to success, and may go far toward helping them convince dealers.

Most significant

This is the final and most significant report of the 5-part series. It discusses the *interrelationship* of various factors affecting service station operation. It may also interest you to know that in preparing this report, the results were sorted, weighed and correlated by the Univac electronic computer.

The survey data, however, should not be interpreted to show cause-and-effect relationships. And no single one of the factors analyzed, of and by itself, can guarantee success. Too, some of the variables may be considered beyond the station operator's control.

Successful stations

Yet, the report shows clearly that there is a marked difference between successful and unsuccessful stations. What's more, most of the variables considered in this report are of such a nature that

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

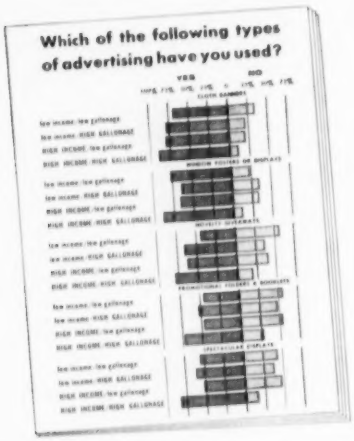
PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED *Dealer Success*

the service station operator has, within his power, the means for reducing any differences between his station and stations that are outstandingly more successful.

In practical terms, this means that of any representative cross-sectional group of stations, some can usually be said to be enjoying a higher income than the average if an established set of conditions is met:

1. Stay open longer.
2. Do more advertising.
3. Offer complete services.
4. Managed by operator with long experience in charge of station.
5. Managed by operator active in community projects and organizations.
6. Owner-operated.
7. Are neat.
8. Managed by better educated operator.
9. Sell TBA.
10. Price of regular gasoline thought by dealer to be lower than in his vicinity.



HERE IS a typical page from Report No. 5 on the Du Pont Service Station Operator Survey. It shows that over 40% of the high-income/high-gallonage stations spend more than $200 annually for off-station advertising. On the other hand, only 6.8% of the low-income/low-gallonage stations spend more than $200 annually for off-station advertising.

Continued middle next column

AT DU PONT PETROLEUM LABORATORY

WILLIAM deB. BERTOLETTE is Technical Service Supervisor of the Fuel Oil Group at the Du Pont Petroleum Laboratory.

He joined the Du Pont Company in 1936 after graduating from Pennsylvania State University with a B.S. degree in chemical engineering. His first assignment was at the company's Jackson Laboratory, where he did analytical work on dyes and other organic chemicals. He was then transferred to the Chambers Works where he became a chemist in the TEL area.

From 1938 to 1946, Mr. Bertolette was stationed at the Baton Rouge plant. There he was in charge of chemical control work, and later became a TEL Production Supervisor. He was transferred to production control work in Wilmington in 1946. In 1950 he joined the Technical Section.

He assumed his present position at the Petroleum Laboratory in 1955. Mr. Bertolette is a member of the American Institute of Chemical Engineers and of the Petroleum Division of the American Chemical Society.

WILLIAM deB. BERTOLETTE

Relative importance studied

Although no absolute dollar values can be assigned to the success-factors, we were able, with the help of the Univac, to analyze their importance relative to the over-all success of a number of stations in the survey sample. You will probably find the bar charts presenting these data among the most interesting and valuable parts of this Survey Report No. 5.

The report also discusses each of the factors individually . . . with the supporting evidence clearly presented in the easy-to-follow bar chart form.

Survey entirely objective

Sponsored by Du Pont, the survey was conducted on a completely impartial basis by National Analysts, Inc. It was nationwide in scope and a part of the continuing market research work conducted by the Du Pont Petroleum Chemicals Division. It follows logically the recent Du Pont survey of service station customer buying habits.

Using the scientifically accurate area sampling method, the survey consisted of personal interviews with 2,633 service station operators. This sample is representative of all the operators in the United States.

Available to marketers

The findings of this report, like the findings of the four which preceded it, are available to all oil companies.

For more information about this survey, just get in touch with one of our representatives at the nearest sales office listed below.

DU PONT
Better Things for Better Living
. . . through Chemistry

Petroleum Chemicals

E. I. DU PONT DE NEMOURS & COMPANY (INC.) *Petroleum Chemicals Division* • *Wilmington 98, Delaware*

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LOS ANGELES 17 — 612 So. Flower St.	MAdison 5-1691	SEATTLE 3 — Room 215, 4003 Aurora Ave.	MElrose 6977
NEW YORK 20 — 1270 Ave. of the Americas	COlumbus 5-2342	TULSA 1 — P. O. Box 730, 1811 So. Baltimore Ave.	LUther 5-5578
PHILADELPHIA 2 — 3 Penn Center Plaza	LOcust 8-3531		

IN CANADA: Du Pont Company of Canada Limited—Petroleum Chemicals—85 Eglinton Avenue East—Toronto 12, Ontario—HUdson 1-6461
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A-2266

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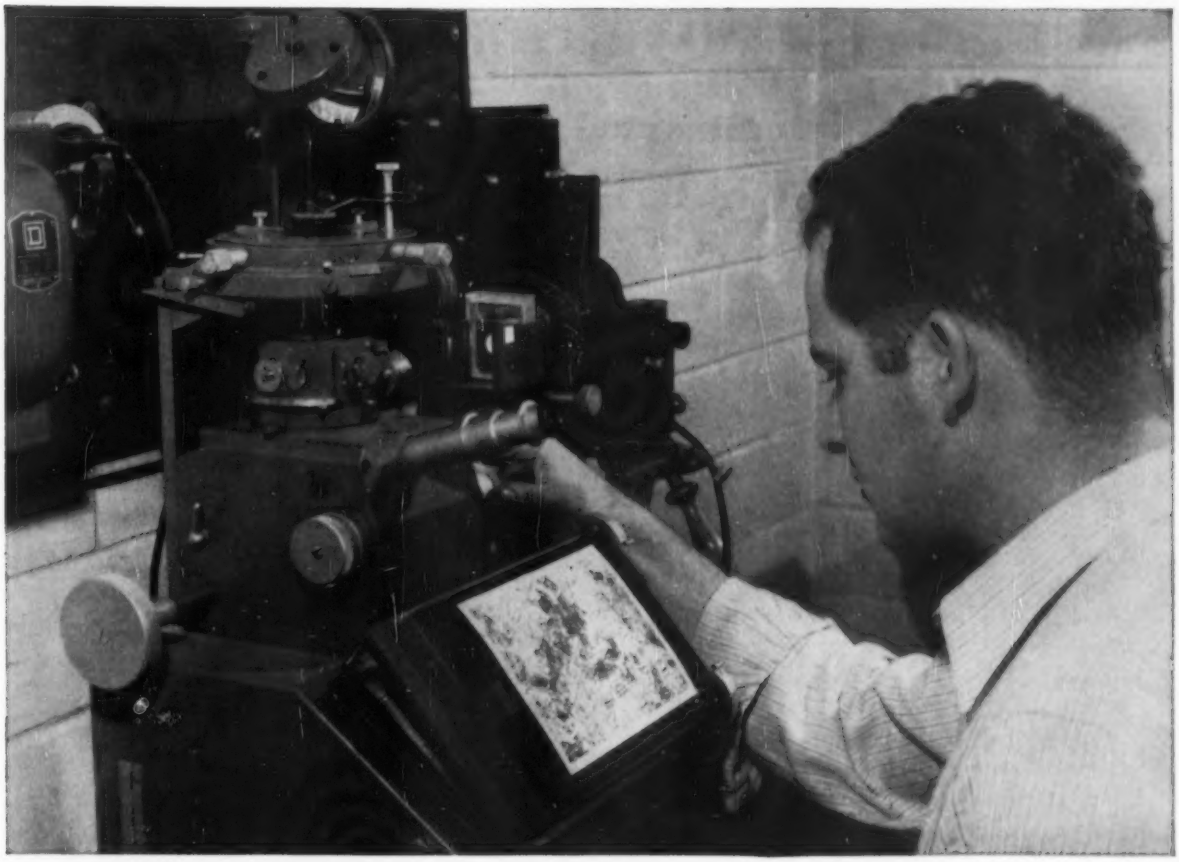


Magnified a thousand times . . .

Sheffield Alloy Steel must show FAULTLESS QUALITY

SHEFFIELD

ARMCO

High Strength

•

Shef-Ten

•

Forging Quality

•

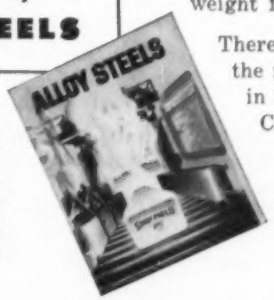
Aircraft Quality

ALLOY STEELS

This man at the microscope is one of a team of experts who guard the quality of Sheffield Alloy Steels from furnace charge to finished steel. Theirs is a far-reaching responsibility. For example, nowhere in all the wide range of Sheffield Alloy Steel uses is quality so important as in aircraft steels. Priceless human lives and a ship worth millions of dollars might be at stake if a tiny flaw went undetected.

That's why Sheffield aircraft quality steel is made only from the heart of the ingot. Through every step of Sheffield steelmaking, quality is constantly assured by the most advanced optical, chemical, electronic and mechanical quality controls and tests. Result: Sheffield Alloy Steels rigidly meet the demands of high strength for unquestionable safety; minimum weight for utmost efficiency.

There can be no compromise with quality for the big air transports and the mighty jets. Get this same standard of consistently high quality in Sheffield Alloy Steels tailored to your specific product demands. Contact our Houston office for engineering counsel and cooperation.



Get your copy of "ALLOY STEELS"

If you're a manufacturer or otherwise engaged in industries served by alloy steels, write for your free copy of this Sheffield booklet.

SHEFFIELD STEEL

DIVISION

ARMCO STEEL CORPORATION

SHEFFIELD PLANTS: HOUSTON • KANSAS CITY • TULSA

For more data on advertised products, use Readers' Service Cards, last page.

Wagner TRANSFORMERS...THE CHOICE OF LEADERS IN INDUSTRY

Where uninterrupted power is a must...

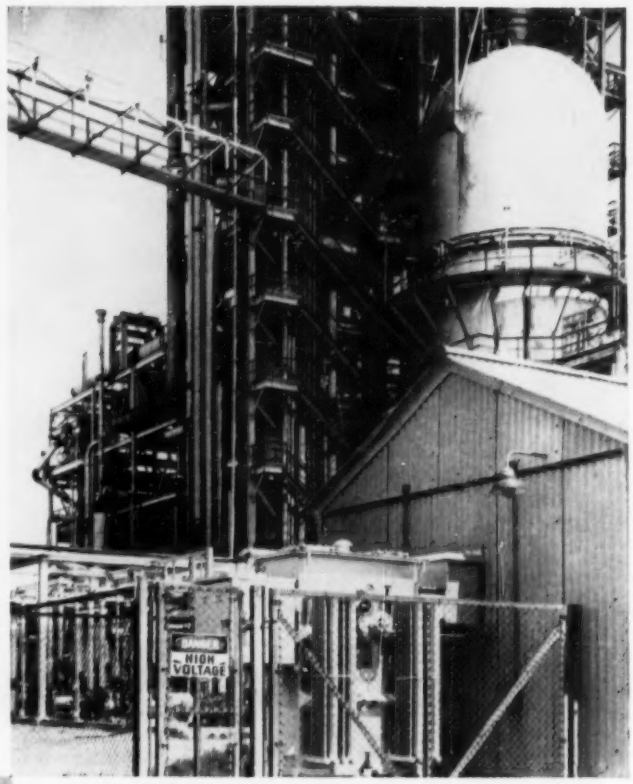
WAGNER UNIT SUBSTATION TRANSFORMERS

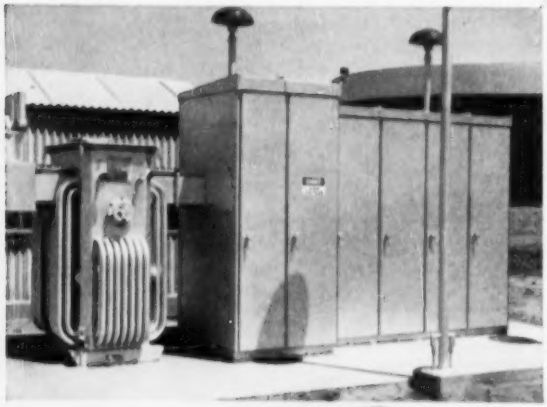
A completely dependable power supply is a vital necessity to an oil refinery. A power interruption of only a few minutes on a "cat cracker," like the one shown at the right, would completely disrupt this important processing operation and cause a shut-down of the entire refinery.

That's why you'll find Wagner Unit Substation Transformers at work at the Carter Oil Company refinery at Billings, Montana.

Wagner transformers are often found in installations where power supply failure would incur great loss because they have a reputation for complete dependability—backed by sixty-five years of transformer building experience.

Wagner Unit Substation Transformers, both liquid-filled and dry-type, are carefully designed to meet distribution requirements. Both liquid-filled and dry-type unit substation transformers are built in ratings through 2000 kva, 15 kv and below—you can choose the type and rating that exactly meets your load-center distribution requirements. Call the nearest of our 32 branch offices, or write us.





The 750 kva, 2400/4160Y to 480 volt, 60 cycle, three-phase, liquid-filled Wagner Unit Substation Transformer feeds the catalytic unit at The Carter Oil Company refinery. At left is shown a 225 kva Wagner substation transformer connected to an outdoor substation at the same refinery. Purchased and installed by The Fluor Corporation, Ltd., Engineers and Constructors for the Petroleum, Chemical and Power Industries, Los Angeles.

* * *

Write for Bulletins TU-205 and TU-214. They give full information on Wagner Unit Substation Transformers. Consult the nearest of our 32 branch offices about your next transformer installation.

Wagner Electric Corporation EST. 1891

Wagner Electric Corporation
6458 Plymouth Ave., St. Louis 14, Mo., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

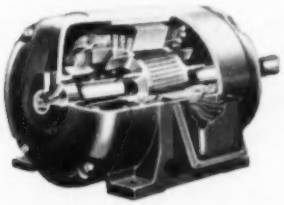
WT56-9

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS-AIR AND HYDRAULIC

TWO WAYS...with Master Unibrakes

STOP-HOLD—Master Type M Magnetic Unibrake Motors. For quick, controlled stopping—especially when you want to hold the load. Spring-setting magnetic release brakes of the friction disc type combine with motor in a compact, integral unit. Sizes—⅛ to 150 H.P.

ROLLING STOP—Master Type D Dynamic Unibrake Motors. Braking is obtained with a unique, patented brake winding superimposed on the stator winding. Simple, compact, with no DC current required, the brake has no moving parts. There is nothing to wear or adjust—braking torque repeats consistently. Particularly recommended for automatic applications which do not require static holding. Sizes up to 30 H.P.



MASTER GEARMOTORS and variable speed drives can be supplied with integrated Unibrakes too. See Master for the perfect power drive for you.

Type M Unibrake

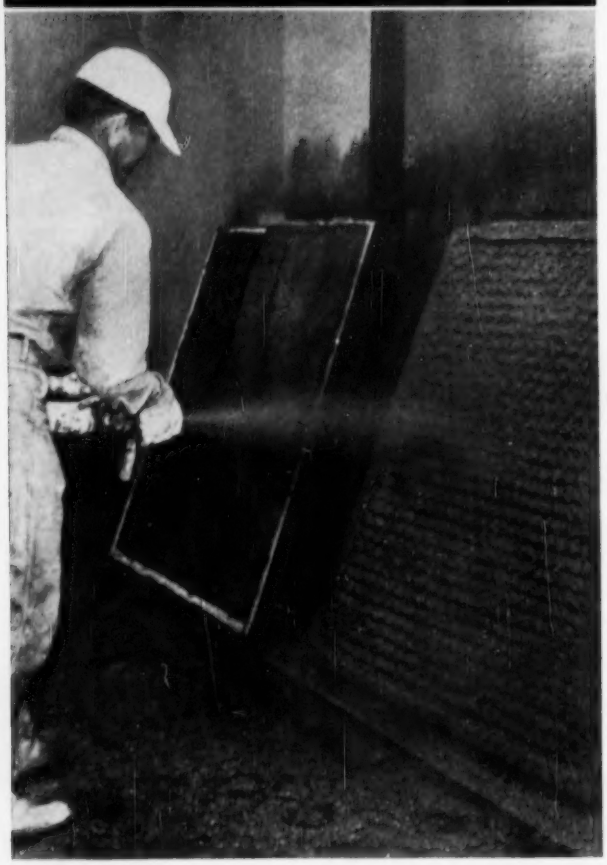
MASTER

THE MASTER ELECTRIC COMPANY
DAYTON 1, OHIO

UNIBRAKE MOTORS

HERE'S WHAT TO LOOK FOR IN REFRACTORY CASTABLES... *and WALSH has them all...*

(thanks to better research and ceramic engineering)



Demonstrating application of Walsh Iron-free castable. Note low rebound loss, excellent nozzle compaction and remarkable trowel finish.

PHOTO PERMISSION REFRACTALL MFG. CO.

- **Uniform grain sizing assuring homogeneous structure for greater strength . . . better bond . . . throughout complete temperature range.**
- **Maximum resistance to abrasion.**
- **Excellent nozzle compaction—smooth trowel finish—low rebound loss.**
- **Highest modulus of rupture without sacrificing low "K" factor . . . wanted feature in light weight castables.**

These and many other advantages add up to performance characteristics that make Walsh Castables an investment in greater production . . . lower cost.

THEY'RE HOMOGENIZED

INSULATING CASTABLES

Lite-Wate Castable No. 50 . . . weight, dry, in place, 50 lbs. per cu. ft. Temp. range 2000° F.

Lite-Wate Castable No. 70 . . . weight, dry, in place, 70 lbs. per cu. ft. Temp. range 2100° F.

SERVICE CASTABLES

H & B Castable . . . weight, dry, in place, 105 lbs. per cu. ft. Temp. range 2700° F.

Super Castable No. 32 . . . weight, dry, in place, 115 lbs. per cu. ft. Temp. range 3000° F.

Something New Has Been Added! Now **Walsh Lite-Wate Insulating Castable No. 50 NISF** and **Super Castable No. 32** are "iron free" . . . contain less than 1% iron content. For details, consult your nearest Walsh distributor or write direct.

WALSH REFRACTORIES CORPORATION — America's Best Clays

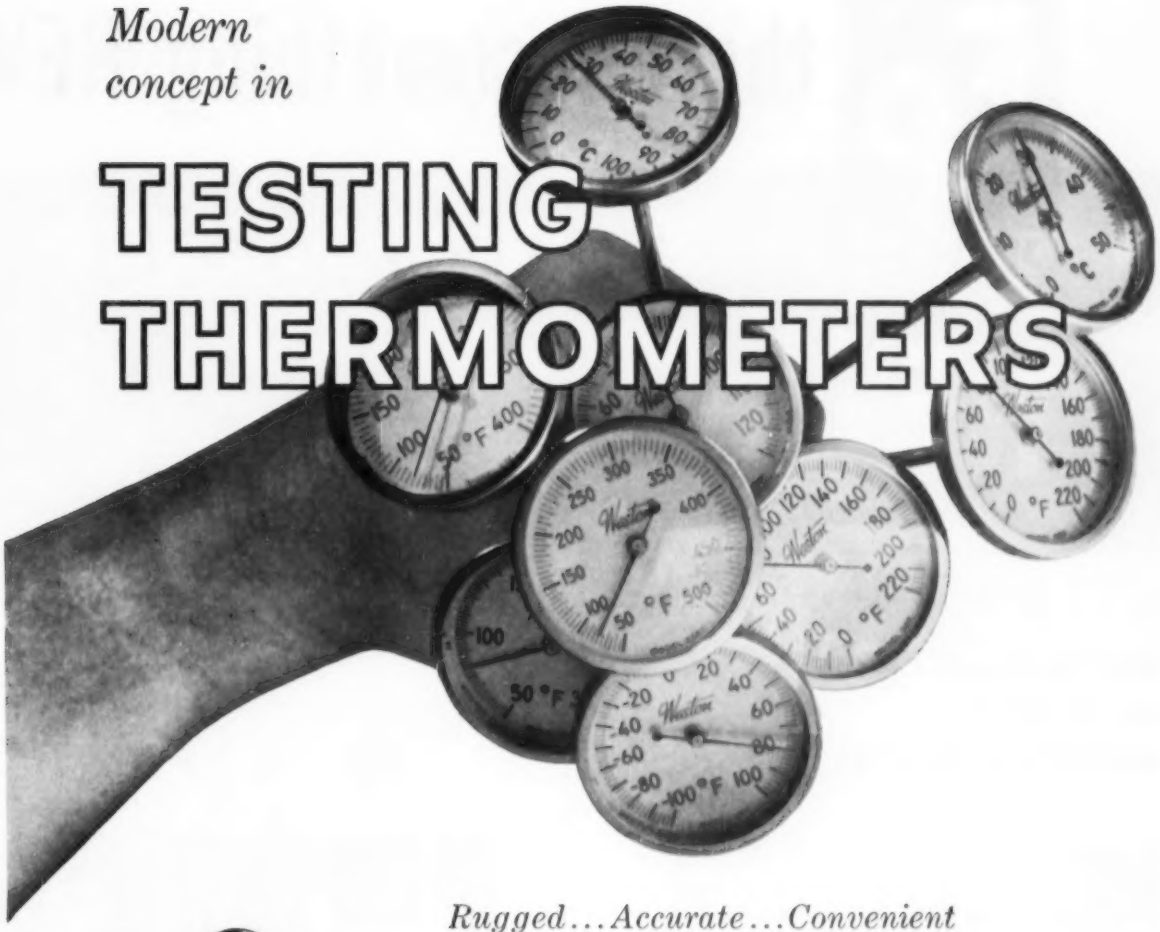
WALSH REFRACTORIES CORPORATION

101 FERRY STREET • ST. LOUIS 7, MISSOURI

FOR OVER 60 YEARS MANUFACTURERS OF HIGH GRADE REFRACTORIES

Modern concept in

TESTING THERMOMETERS



Precision POCKET THERMOMETERS

Dials 1" dia. – spike stem 5" long – 18-8 stainless steel construction – ranges as low as –40F to high as +500F – accuracy ½ of 1% of thermometer range.

General Purpose THERMOMETERS

Dials 2" dia. – 18-8 stainless steel construction – ranges as low as –100F to high as +1000F – accuracy 1% of range.

Model 2282 – standard stem length 8" including hub.

Model 2281 – stem lengths 2½"-4"-6"-9"-12"-18"-24" including threads

Rugged...Accurate...Convenient for laboratory and equipment needs

For laboratory needs, for production testing and inspection, for equipment mounting . . . wherever high sustained accuracy and quick response are essential . . . WESTON all-metal thermometers have been widely adopted because they are more convenient to use, and far more durable and economical. Cases and stems are of 18-8 stainless steel – standard stem length 8" – 2" to 24" length available on order – dials 1¾" dia. – ranges from low as –100F to high as +500F. Require only 2" immersion in solids or liquids. Accuracy ½ of 1% of thermometer range. For the complete story, including data on all-metal thermometers for industrial use, write now for bulletin T-13. Weston Electrical Instrument Corporation, 614 Frelinghuysen Ave., Newark 5, N. J. A subsidiary of Daystrom, Incorporated.

WESTON *all-metal*
THERMOMETERS

EAGLE
EP
PICHER

there's something NEW

NEW

EAGLE-PICHER HYLO

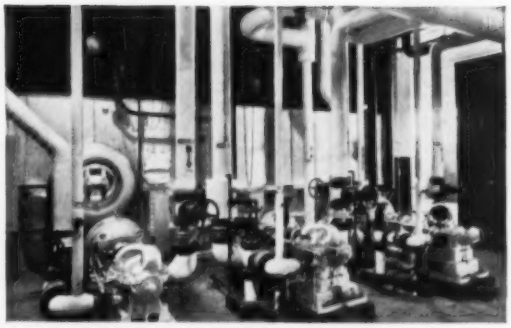
PIPE AND BLOCK INSULATION
Insulates from
1600 F down to 100 F

EASILY WORKABLE
EASY TO APPLY
UNAFFECTED BY MOISTURE

Eagle-Picher HYLO is a combination of special inorganic silicas and asbestos fibers. It is non-brittle, easily workable and keeps its high thermal efficiency and strength, even after exposure to excessive heat and moisture.

HYLO's internal shrinkage is lowest of all tested comparable insulations. Does not crack or open up from shrinkage, thus retaining highest efficiency.

"Nesting O.D." pipe covering sizes provide accurate, tight fits for multiple layer construction. Every size and thickness fits over or into another size and thickness, permitting a wide range of unusual assemblies and the advantage of building up many thicknesses from a limited number of "prime" units.



Eagle-Picher HYLO is designed for insulating both flat and curved surfaces, and is especially suitable for conditions where the surface is irregular and where you find an easy-to-cut and easy-to-apply insulation essential.

The addition of HYLO and 85% MAGNESIA PIPE AND BLOCK to Eagle-Picher's line of industrial insulations makes available a complete group of effective insulations for every industrial application. Complete information about our entire line available upon request. Why not write today?

Since 1843

EAGLE
EP
PICHER

EAGLE-PICHER

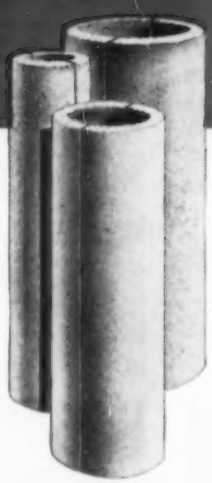
The Eagle-Picher Company • General Offices: Cincinnati 1, Ohio

PRODUCING A COMPLETE LINE OF INDUSTRIAL INSULATIONS

under the Eagle-Picher label

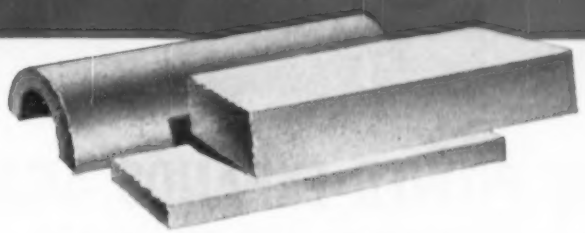
NEW EAGLE-PICHER 85% MAGNESIA

PIPE AND BLOCK INSULATION recommended for insulating heated pipes and equipment operating at temperatures up to 550-600 F.



EAGLE-PICHER PIPE SECTIONS

Extreme light weight
Low thermal conductivity
Attractive smooth finish

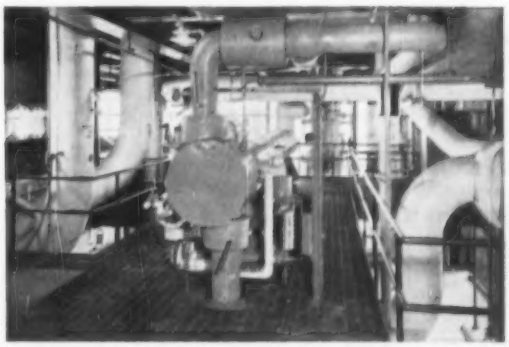


EAGLE-PICHER 85% MAGNESIA BLOCKS

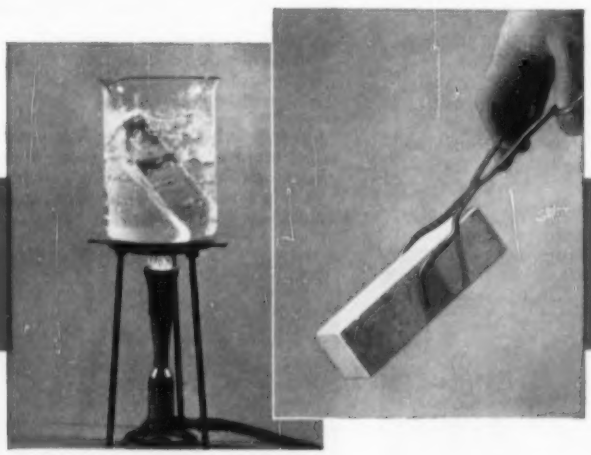
• Smooth surfaces • Uniform thickness • Sharp true edges

Pipe sections! Blocks!

EAGLE-PICHER 85% MAGNESIA combines light weight, high strength, low conductivity, resistance and high dimensional stability . . . factors that assure superior performance, extra years of service.



Pipe coverings and blocks are molded to exact size and thickness. The result is a smooth "rind" appearance that is not only attractive, but tends to strengthen the structure—also provides superior "suction" for holding cement finishes.



After a 24-hour bath in boiling water, EAGLE-PICHER 85% MAGNESIA shows no evidence of disintegration nor change in shape—a quality derived from its chemically "set" monolithic structure.

For more data on advertised products, use Readers' Service Cards, last page.

NEW VERMILION STATION
near Danville, Illinois, was designed by Sargent & Lundy. 75,000-kw Unit 1 went on the line in May 1955. 100,000-kw Unit 2 goes in service October 1956.

ILLINOIS POWER EXPANDS AGAIN!

Latest 175,000-kw station is protected by Permutit-conditioned water

To meet rapidly growing needs, progressive Illinois Power Company has built two high-pressure stations within two years.

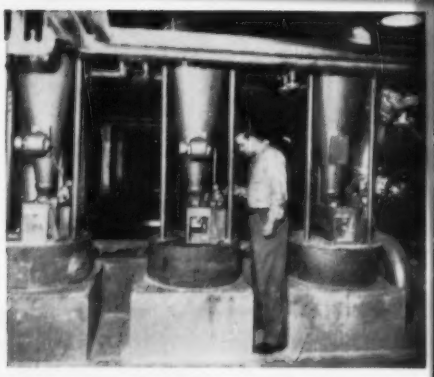
75,000-kw Hennepin Station went on the line in 1954. Its 1450 psig boiler requires *feedwater of the highest quality*. To produce this makeup, Permutit Demineralizers were installed.

When Illinois Power built the new Vermilion Station, Permutit water conditioning was installed again. To protect its turbine and boiler, all makeup is demineralized by the Permutit ion exchangers shown.

For Vermilion's big cooling-tower system, a different grade of water is most economical. The Permutit Precipitator and Filters shown produce it.

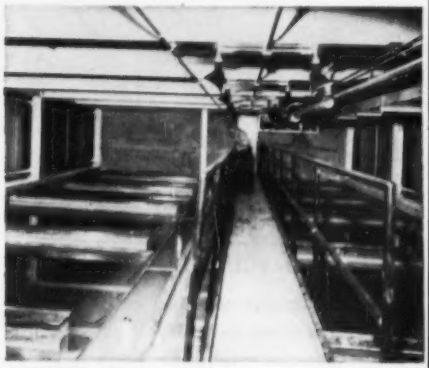
You can get this complete protection for your plant. We'll gladly help. Write outlining your problem. The Permutit Company, Dept. PR-7, 330 West 42nd Street, New York 36, N. Y. Permutit Co. of Canada, Ltd., 207 Queen's Quay, Toronto 1, Ont.

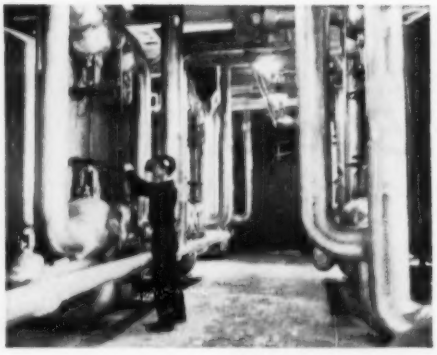
PERMUTIT®
WATER CONDITIONING
Equipment • Resins • Experience



Chemical Feeders: 1st step in treating all water for plant use is accurate dosages of lime and alum for treatment in Precipitator.

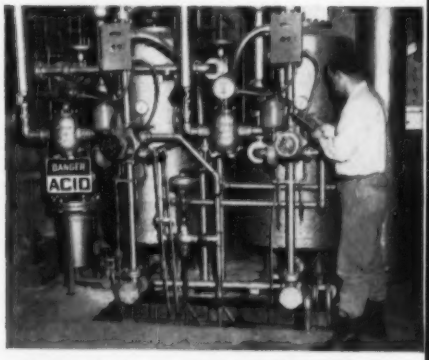
1800 gpm Precipitator clarifies and softens cold river water. Dealkalizes, too—eliminating need for degasifier in demineralization.





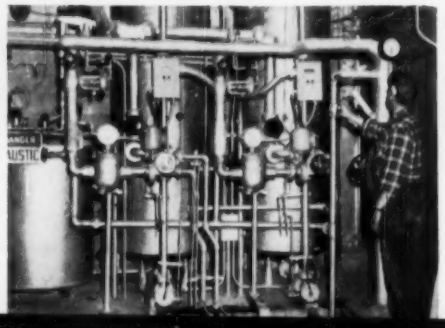
Pressure Filters further clarify Precipitator effluent . . . deliver finished water to protect Vermilion Station's 53,000 gpm cooling-tower system.

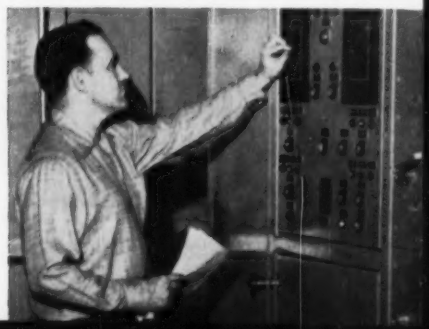
Anion Exchangers: Permutit S resin removes the few remaining minerals . . . protects Vermilion Station's turbine from troublesome silica deposits.



Cation Exchangers: Permutit Q resin removes metallic cations from Precipitator effluent to prevent boiler scale . . . allow high heat-transfer rates.

Control Cubicle operates demineralizers. Determines end-point, then sequences backwashing, regeneration, rinsing, return to service. Even prepares regenerant charges.





Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Published by The Pfaudler Co., Rochester, N.Y.

Get continuous centrifuging in your continuous processes

For *continuous removal* of solids from one or two liquids . . .

For *continuous concentration* of solids by removal of liquid from slurries . . . and discharge of solids in a predetermined dry state . . .

It is no longer necessary for your centrifuging to be an expensive and time-consuming "batch" type operation.

While rotating at full speed, the Titan Superjector Centrifuge discharges solids deposited within the centrifugal bowl and thus cleans itself.

How it works

A simple yet unique design enables the Superjector to work automatically like no other centrifuge.

Solids are discharged through peripherally placed slots. These slots periodically are opened and closed by a telescopic action actuated by hydrostatic pressure. This pressure is built up by centrifugal force.

The concentration of solids and clarity of liquid produced can be adjusted within wide ranges. Solids can easily be concentrated to as low as 40% moisture content. Liquids can be rendered crystal clear.

If you can see uses for such an automatic centrifuge in your operations, write for your free copy of Bulletin No. 930, "Titan Superjector Centrifuge." Or ask your Pfaudler representative for details.

Now—fastest drying of corrosive products with Pfaudler dryer-blender

How do you go about drying highly corrosive products in your plant?

If you're not using a Pfaudler conical glassed steel dryer-blender you may be spending too much time and money on this process.

4-day drying yield ready in 7 hours... reported one user making product containing acid halides. Filling and emptying the Pfaudler conical glassed steel dryer-blender is quick and easy. It has a 1½ foot diameter opening for filling and a single 8 inch discharge nozzle for the 4 ft. and 6 ft. units.

Most of the labor cost and time previously spent handling trays of vacuum dryers is saved.

When in use, the dryer slowly revolves, tumbling its contents and quickly providing an evenly blended, evenly dried product.

These structural features built into the unit make it your fastest and most economical tool for drying and blending highly corrosive products:

- Solid one-piece construction of inner vessel for maximum strength, greatest corrosion resistance and easiest cleaning.
- Space between inner vessel and spherical portions of jacket heads insures effective drying with no waste of heat.
- No joints or clamps to break up the drying surface area. This heated surface area is maximum; therefore drying time is shortest.

At Eastman Kodak Company this Pfaudler dryer-blender, used for drying a corrosive organic halide, has reduced time required by previous methods (4-6 days) by 75%.

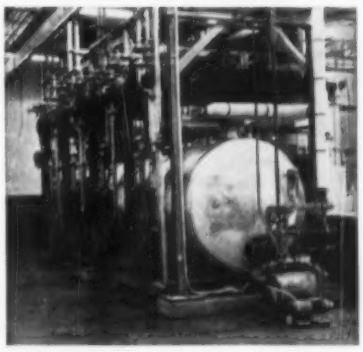
- Vacuum exhaust tube is located up and out of the product while the unit is in operation. There it is able to remove vapors most efficiently.

Dries acids and alkalies

You can use Pfaudler conical dryer-blenders for every acid except hydrofluoric and for alkalies up to pH12 at 212° F. Thus you get the same flexibility you are already familiar with in Pfaudler glassed steel reactors.

These dryers range in volume up to 165 cu. ft. working capacity. They are available in four different diameters: 2 ft., 4 ft., 6 ft., and 8 ft. Internal pressures may range from full vacuum. Each unit is tested to meet ASME code specifications. Write for Data Sheet 26.

How Sylvania heats, cools four separate solutions to ±1° accuracy . . . in one system



The problem at Sylvania Electric Products, Inc. was to find a system that would hold four different solutions to within 1° F. of a predetermined temperature. These solutions may be required for use between 55° and 70° at any time, and are supplied at anywhere from 38° to 78° F.

Thus, the system must either heat the solution or cool it. It must also vary the degree of heating or cooling. It must switch from heating to cooling, depending on change of set point.

Now in operation at Sylvania's Seneca Falls, N. Y. plant is the Pfaudler system shown (left). It does all the thermal gymnastics mentioned, and still holds to within 1° accuracy on all four solutions.

This system, completely designed and equipped by Pfaudler, includes heat exchangers, all control valves, the heating equipment, refrigeration equipment, automatic controls, panel board and all auxiliary equipment. It is typical of the type of project engineering Pfaudler now offers.

For more data on advertised products, use Readers' Service Cards, last page.

PROVED BY PERFORMANCE OF *OVER A MILLION* TRAPS!

YARWAY IMPULSE STEAM TRAP

the only moving part

...a small stainless steel valve that literally floats on the condensate load. Gets equipment *hot in a hurry*—and *keeps it hot!*

Using a theory of thermodynamics never before applied to steam traps, the YARWAY Impulse Trap revolutionized the industry *20 years ago.* Today over a million YARWAY traps have successfully proved the Impulse principle.

Advantages like the following continue to win new users, convince old users to standardize:

- **QUICK HEAT-UP AND EVEN TEMPERATURES OF EQUIPMENT**
- **GOOD FOR ALL PRESSURES WITHOUT CHANGE OF VALVE OR SEAT**
- **SMALL SIZE—LIGHT WEIGHT**
- **ONLY ONE MOVING PART**
- **STAINLESS STEEL—minimum maintenance**
- **WON'T FREEZE UP**
- **A COMPLETE LINE of sizes and types for every requirement**
- **IMMEDIATELY AVAILABLE from 270 local Industrial Distributors**

For free Trap Selector, or 24 page bulletin, write
YARNALL-WARING COMPANY 128 Mermaid Avenue, Philadelphia 18, Pa.

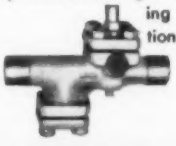
THERE'S A YARWAY IMPULSE STEAM TRAP FOR EVERY NEED

SERIES 60 and 120
For all *normal* trap requirements, pressures to 400 and 600 psi.

½" No. 20-A
For *light loads* on tracer lines, steam mains, small presses, etc.

SERIES 40
For *heavy loads* requiring extra high capacity steam traps

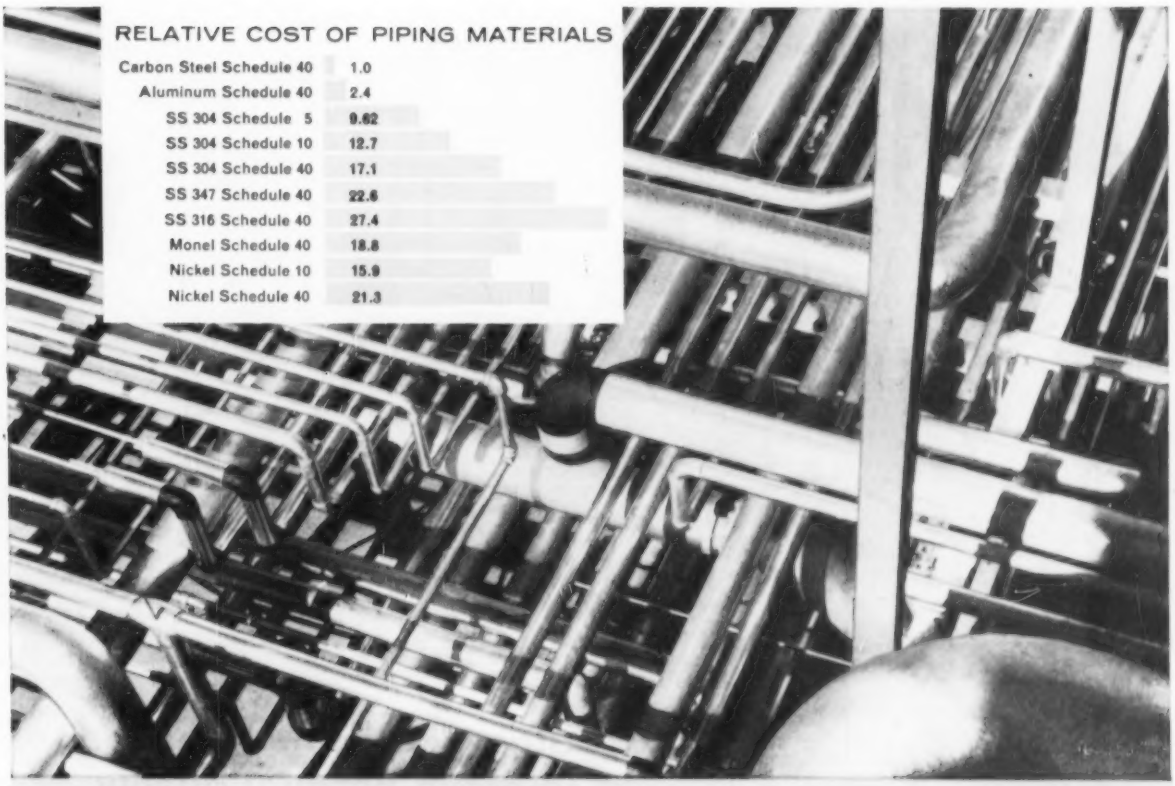
INTEGRAL-STRAINER HIGH PRESSURE TRAP
For *high pressures, high temperatures.* (Flanged or welding connections.)



YARWAY

IMPULSE® STEAM TRAP

OVER 1,000,000 YARWAY IMPULSE STEAM TRAPS USED



RELATIVE COST OF PIPING MATERIALS	
Carbon Steel Schedule 40	1.0
Aluminum Schedule 40	2.4
SS 304 Schedule 5	9.62
SS 304 Schedule 10	12.7
SS 304 Schedule 40	17.1
SS 347 Schedule 40	22.6
SS 316 Schedule 40	27.4
Monel Schedule 40	18.8
Nickel Schedule 10	15.9
Nickel Schedule 40	21.3

Corrosion Resistant
REYNOLDS ALUMINUM PROCESS PIPE
. . . the pipe that lowers costs

Many of the largest chemical and petroleum processors use a lot of aluminum pipe. They call it the most economical corrosion resistant piping product available.

That's important. Aluminum resists corrosive effects of chemicals like hydrogen peroxide, nitrogen solutions, many acids, alcohols, foods . . . and petroleum products like sweet and sour crudes, raw or refined gases, kerosene, gasoline, naphthas.

And aluminum pipe possesses other advantages. Light weight and easy weldability make for low-cost installation . . . it's nonsparking—assures safety . . . smooth inner surface reduces friction.

Standard Aluminum Fittings are available from leading manufacturers. For more information on how you can save with Aluminum Process Pipe, consult the nearest Reynolds Office listed under "Aluminum" in classified telephone directories, or write to *Reynolds Metals Company, P.O. Box 1800-CT, Louisville 1, Kentucky.*

Write for new brochure "Reynolds Aluminum Process Pipe"

REYNOLDS NEW DUPLEX TUBE for steam traced piping. It does away with cost of external steam jackets or steam tracer tubes—the steam line is part of the aluminum pipe. Saves labor costs, material costs, insulation costs.

The Finest Products Made with Aluminum are made with REYNOLDS ALUMINUM

See "FRONTIER", Reynolds exciting dramatic series, Sundays, NBC-TV

For more data on advertised products, use Readers' Service Cards, last page.

✔ Stop entrainment losses
✔ Improve product quality
✔ Cut process costs

with METEX Hi-Thruput MIST ELIMINATORS

Collection and recovery of valuable liquid products — removal of liquid particles harmful to subsequent processes — reduced equipment maintenance and decreased air pollution . . . these are but a few of the possibilities METEX Hi-Thruput Mist Eliminators offer to alert process and project engineers.

METEX Hi-Thruput Mist Eliminators, installed in a process tower or vessel, effect sharp separation of entrained liquids within a wide range of vapor velocities. Pressure drop is negligible. Quality and yield are increased. High removal efficiency is maintained, even at extreme temperatures, due to free-drainage of impinged liquids. Liquid slugs cannot enter turbines or compressors. Coke formation is minimized and life expectancy is substantially increased even under adverse conditions.

Where solids may be formed in the mesh because of decomposition, polymerization, crystallization or freezing, METEX Hi-Thruput Mist Eliminators provide up to three times the service life of conventional units.

In any processing equipment or vessel where liquid entrainment is a contributing factor in design or operation, METEX Hi-Thruput Mist Eliminators assure higher production, better processing and lower operating and maintenance costs.

For complete information and specifications, write today for your copy of Bulletin ME-106, illustrating and describing METEX Mist Eliminators for all process equipment.

METEX QUALITY PRODUCTS

6-075

METAL TEXTILE CORPORATION
ROSELLE, NEW JERSEY

METAL TEXTILE CORP. OF CANADA, LTD., HAMILTON, ONTARIO
Representatives in principal cities throughout the world

Now...a *New* advance in...

Gauge Safety!

Another step ahead in Marsh Gauges: the new Marsh "Safecase". Down to the final detail this gauge is developed for those applications where an unexpected surge of heavy, explosive over-pressure can occur.

In the "Safecase" a solid metal barrier protects the entire face. But, still more important, the *entire back* of the gauge is a thin, ductile plate, designed to open out when subjected to abnormal pressure. Back plate is held firmly to the case by two holding screws and cannot be dislodged by a pressure blowout.

In exhaustive tests it has never been possible to shatter the crystal or create any other dangerous condition in a "Safecase" gauge with its safety-release back. The accompanying illustration shows the result of one of a series of tests in which blank cartridges were fired in the back of the case without even breaking the crystal. Think what that means in safety to operating men!

Yes, an important development . . . but merely the kind you would expect from the manufacturer who originated the "Connoweld" tube, the "Marshalloy" case, the Mastergauge movement and practically all of the major advancements in pressure gauges. Ask for up-to-the-minute information.

Pressure of explosive force merely opens out safety back

Instead of depending on blow-out plugs, entire back of Safecase Gauge is designed to yield to over-pressure. Photo at left shows actual result of firing cartridge within back of case. Safety-release back exhausted pressure. Front remained intact.

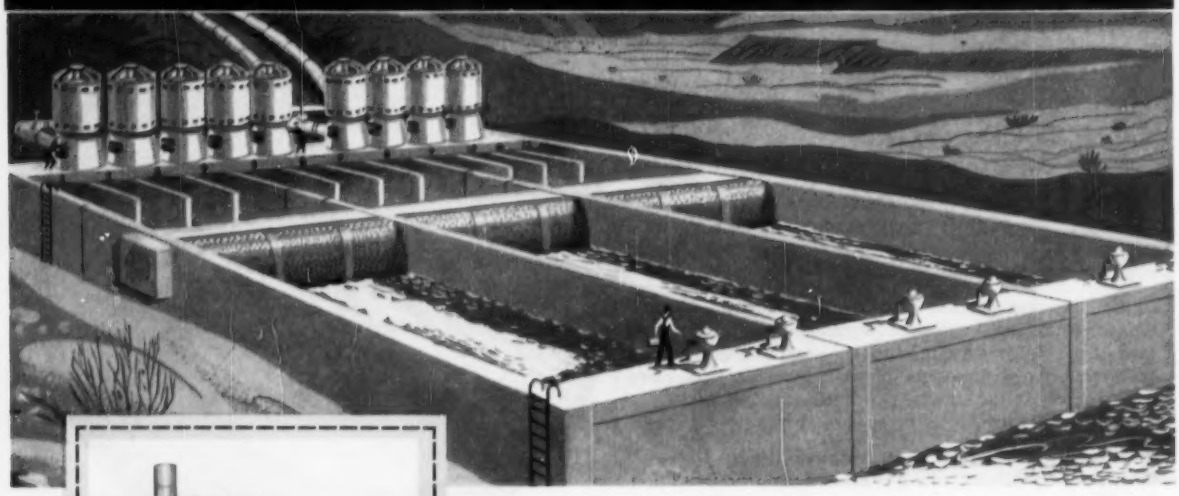
MARSH INSTRUMENT CO.
Sales affiliate of Jas. P. Marsh Corp.
Dept. R, Skokie, Ill.
HOUSTON BRANCH PLANT:
1121 Rothwell St., Sect. 15, Houston, Texas
Marsh Instrument & Valve Co. (Canada) Ltd.,
8407 103rd St., Edmonton, Alberta, Canada

"THE STANDARD OF ACCURACY"

MARSH GAUGES

For more data on advertised products, use Readers' Service Cards, last page.

Giant new Tidewater refinery selects Byron Jackson pumps for 400 MGD service



TWO STAGE BJ PUMP shown without discharge head and motor.

SPECIAL ENGINEERING REPORT AVAILABLE:

A special engineering report with detailed flow diagrams and color photographs is available. Also, a factual full-color motion picture report can be arranged on request.

Tidewater Oil Company's new Delaware Flying A Refinery is one of the world's largest new refineries. This giant refinery—15 miles south of Wilmington—will use more than 16 million gallons of water per hour. To accomplish this mammoth pumping job, Tidewater and C. F. Braun & Co. (engineers and constructors) selected nine BJ 2000 hp vertical river intake pumps, with provision for installation of three more units.

BJ Pre-Tested the Actual Installation

Because of the special intake system and the untested hydraulic problems involved, it was decided to pre-test the actual pumping conditions. A scale model intake installation—including nine pumps—was constructed in Byron Jackson's Los Angeles hydraulic laboratory. Actual field operations were duplicated in this model. All tests confirmed the correctness of engineering and pumping specifications. In addition, before delivery, Byron Jackson performed exacting hydraulic tests on each of the nine pumps. *These giant pumps tested to an 89.5% efficiency!*

Each BJ pump will be driven by a 2000 hp electric motor at 600 rpm against a total head of 184 feet. Because of the brackish salt water, pump cases, columns and impellers are made of high alloy stainless steel.

BJ
SINCE 1872

Byron Jackson Pumps, Inc.
A Subsidiary of Borg-Warner Corp.
P.O. BOX 2017A, TERMINAL ANNEX • LOS ANGELES 54, CALIFORNIA

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to meet exacting lubrication standards, specify

ENJAY PARATONE®

viscosity-index improver

Paratone is engineered specifically to help blenders and refiners meet the rigorous requirements of both hot- and cold-weather lubrication. It produces a lubricant combining the cold-starting properties of a light oil with the low consumption rate of a heavy grade.

Our technicians are constantly working with oil companies and leading engine manufacturers to develop lubricating oil additive formulations—using a wide variety of base stocks—to meet military and commercial specifications.

Write, wire or phone the Enjay Company—your only source of a *complete* line of additives (Paramins ®) for fuels and lubricants.

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ENJAY COMPANY, INC., 15 WEST 51st STREET, NEW YORK 19, N. Y. • Other offices: Akron, Boston, Chicago, Tulsa

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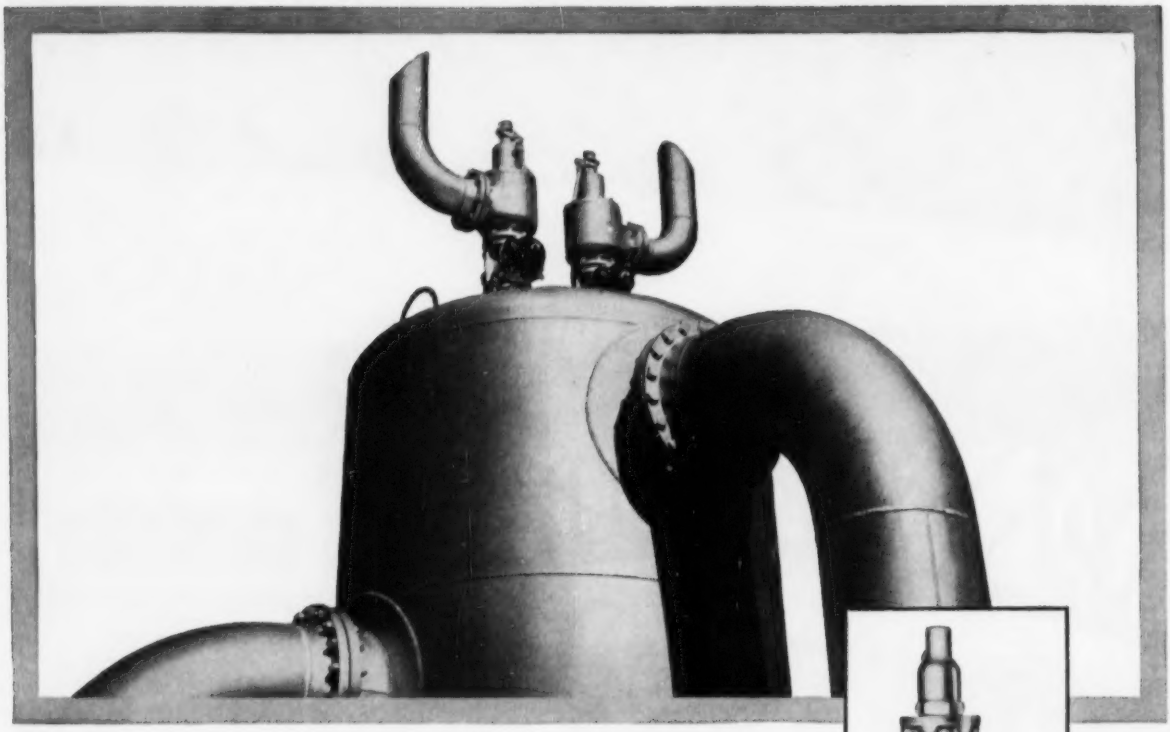

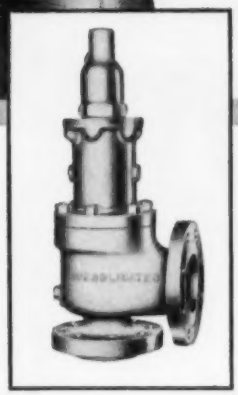

★ **Economical "2 in 1" Design**
★ **Peak Performance**
★ **Absolute Protection**
★ **Maximum Interchangeability**

CONSOLIDATED SAFETY RELIEF VALVES GIVE YOU ALL FOUR—AND MORE

Consolidated Safety Relief Valves satisfy *every* requirement of the most advanced processing facilities. Valve action is *consistently* positive. You get peak performance even where discharge lines are long or there is low "superimposed" back pressure in the relieving system!

The Standard type can be converted to Bellows type *in the field*. Center-to-face dimensions of inlet and outlet are such that you can interchange these valves with the safety relief valves of other manufacturers. Real flexibility of application that cuts inventory costs! Optically-ground flat seating surface and fewer functional parts than comparable valves contribute greatly to easier, more economical maintenance.

Get top economy and absolute protection with Consolidated Safety Relief Valves. Full range of sizes and pressures available. Write for Catalog 1900 for complete information.

CERTIFIED AND APPROVED. Both Standard and Bellows Valves are approved under API-ASME and ASME Unfired Pressure Vessel Codes and are certified by the National Board of Boiler and Pressure Vessel Inspectors.

In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario

CONSOLIDATED SAFETY RELIEF VALVES

A product of **MANNING, MAXWELL & MOORE, INC.** TULSA, OKLAHOMA

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here's how to get more for your money!

Call your nearby Tube Turns' Distributor. He can fill *all* your needs in welding fittings and flanges—aluminum as well as other piping materials. He provides industry's most complete line—over 4,000 top quality items —different sizes, types, schedules, materials; hence, this one source saves you purchasing time, cuts red tape. He acts as your warehouse. He gives you prompt delivery. And through him, Tube Turns' Engineering Service gives you valuable application help. To take advantage of this cost-cutting service, specify and buy TUBE-TURN Welding Fittings and Flanges.

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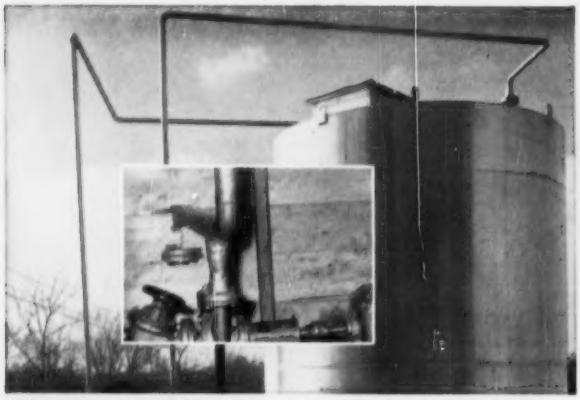
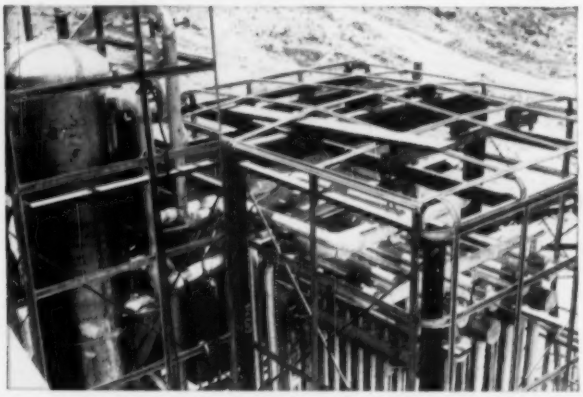
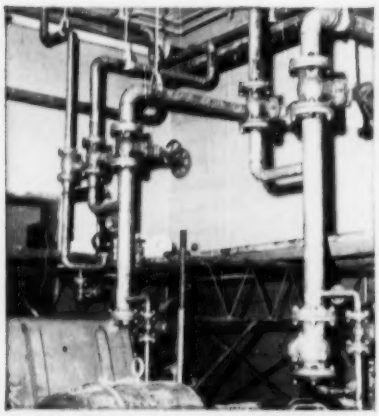
helps you apply aluminum piping on jobs like these...



Oleic Acid Storage: Here, 2" aluminum lines carry oleic acid in this installation for a rubber company. TUBE-TURN Aluminum Welding Fittings are used for directional changes. Insert shows a compact combination of these fittings at a pump . . . an elbow, tee, reducer and flange.

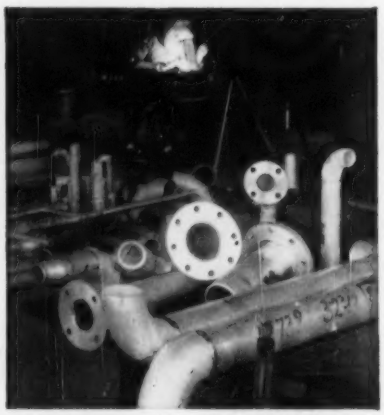


Oxygen Plant: TUBE-TURN Welding Fittings were used throughout this 25 tons-per-day oxygen plant for ore recovery. Here, operating temperatures range from 100°F to −320°F. Picture above shows reversing heat exchangers and fractionating tower prior to being enclosed in insulating shell.



Catalyst Piping: Aluminum piping and fittings were specified for certain services in this new TCR bead catalyst plant to prevent contamination of the catalyst. TUBE-TURN Welding Fittings and Flanges were employed in all aluminum lines from 1" to 10". Result: Lines are permanently leak-proof—maintenance is minimized.

Refinery Wax Coils: Originally, retubing of seven wax sweaters in a large refinery called for coils of another metal. Switch to aluminum piping and TUBE-TURN Welding Fittings saved $50,000 in material costs! Each unit required 900 TUBE-TURN 180° Welding Returns of 1" OD.



Fast Fabrication: TUBE-TURN Welding Fittings and Flanges are dimensionally accurate. Rigid inspection by Tube Turns assures true circularity and uniform wall thickness. Result: Alignment is perfect; fabrication is faster; installation simplified.

NEW BOOKLET—This new Tube Turns' catalog gives helpful information on aluminum pipe, fitting and flange materials. Mail the coupon for your free copy.

TUBE TURNS, Dept. Y-4
224 East Broadway, Louisville 1, Kentucky

Please send free copy of new catalog on Aluminum Fittings and Flanges.

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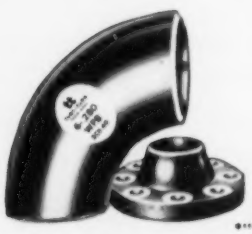
Available from your nearby TUBE TURNS' distributor



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LOUISVILLE 1, KENTUCKY

your "rolling pipe line"

More than 2600 Olin Mathieson tank cars are in service every day shuttling between a score of production points and our customers to assure dependable delivery of Mathieson Chemicals.

In a sense, they form a "pipe line" connecting major consuming and producing areas. And, they perform the important function of balancing out local shortages and surpluses.

If you're ever caught short of an essential chemical raw material, the flexibility of a multi-plant producer can prove invaluable. Our "pipe lines" carrying caustic, chlorine, ammonia, sulphuric acid, methanol and organics may be the answer to your supply problems. Talk it over with an Olin Mathieson representative soon.

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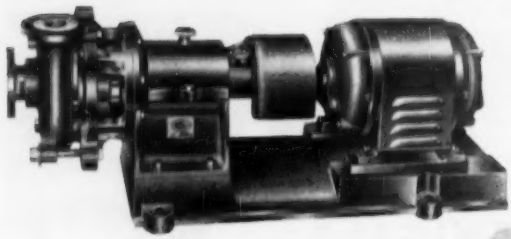
Highly potent insecticides begin with

WILFLEY ACID PUMPS

WILFLEY ACID PUMPS handle many of the basic ingredients used in the manufacture of insecticides. Whenever you see the name Wilfley on a centrifugal pump, you know that here is the ultimate in dependability, efficiency and economy. These famous pumps are known the world over for delivering continuous, trouble-free performance on even the most difficult pumping jobs.

WILFLEY ACID PUMPS are available with pumping parts of the machinable alloys as well as plastic to meet all requirements. Write or wire for complete details.

Individual Engineering on Every Application



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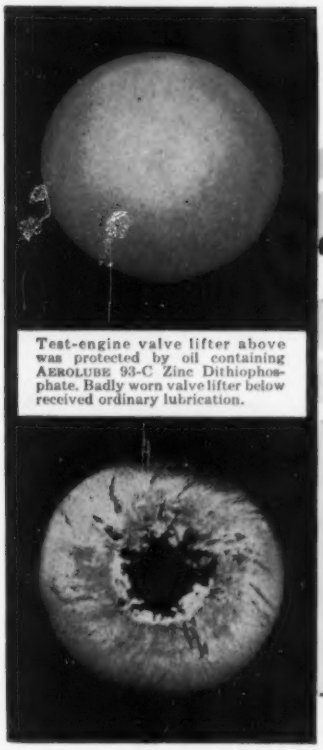
Wilfley Acid Pump
"COMPANIONS IN ECONOMICAL OPERATION"
Wilfley Sand Pump

AEROLUBE® 93-C

ZINC DITHIOPHOSPHATE

Fights Wear... cuts engine repair



Test-engine valve lifter above was protected by oil containing AEROLUBE 93-C Zinc Dithiophosphate. Badly worn valve lifter below received ordinary lubrication.

Nine out of ten new cars today are delivered with zinc dithiophosphate in the initial fill or "break-in" oil.

The reason? Major automotive manufacturers have found zinc dithiophosphate the most effective wear inhibitor, particularly in the valve train mechanisms of modern V-8 high-compression engines.

Best of the zinc dithiophosphates is Cyanamid's AEROLUBE 93-C, specially modified to give superior antiwear characteristics. It also controls oil oxidation and checks formation of oil-insoluble sludges and varnishes. It retards formation of peroxides and organic acids that corrode cadmium-silver and copper-lead bearings.

Very light in color, compatible with all lube oil stocks and other additives, AEROLUBE 93-C may be used alone for API Service MM and initial fill requirements, or with detergents such as AEROLUBE 90 for heavy-duty formulations.

Whether you are formulating lube oil for initial fill or day-to-day service, try AEROLUBE 93-C Zinc Dithiophosphate for better control of wear, oil oxidation and bearing corrosion.

CYANAMID

AMERICAN CYANAMID COMPANY
REFINERY CHEMICALS DEPARTMENT
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Monel Bubble Cups and Tray for top of new fractionating tower completely engineered and fabricated by Fritz W. Glitsch and Sons, Inc., Dallas, Texas. Notice Monel weirs and baffles.

Here's where Monel proves year-after-year resistance to common tower-top corrosives

Tower-top corrosion *can* be held within practical limits.

Monel* nickel-copper alloy bubble caps proved *that* long ago. Their record . . . at temperatures up to 500°F. . . . shows outstanding resistance to the aqueous hydrochloric and sulphuric acids and the corrosive salts commonly present in this critical upper section.

Today, for towers handling corrosive streams, Monel alloy is preferred in this location.

The men with the sharp pencils say Monel alloy costs less per pound than other commercially available alloys able to withstand the corrosion in tower tops.

Fabricators such as Fritz W. Glitsch & Sons, Inc., find it is easy to form . . . lends itself well to lined or clad construction. Increasingly, they find it specified not only for caps and trays but also for distribution pipes, fittings, linings, the shell itself and overhead condensers.

Another advantage. Monel equipment can be field erected and easily field repaired. No heat treatment after welding is required to maintain corrosion resistance.

How is your tower down-time record? If it's not what it should be and corrosion is the cause, look into the possibilities of Monel alloy construction. Simply write Inco's Corrosion Engineering Section. *Registered Trademark

The International Nickel Company, Inc.
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INCO TRADE MARK **Nickel Alloys Perform Better Longer**

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exclusive
proven
construction

Prevents Freezing of

OCECO V-130 Conservation Regulators

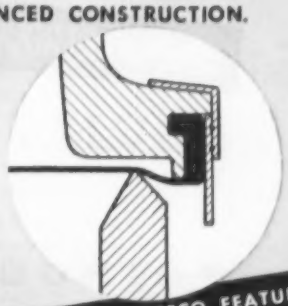
Positive flexing action of pliable cold and heat resistant membrane, held under tension, peels off icy formations without exceeding set pressures.

NEVER A REPORTED CASE OF VALVE FREEZE-UP

Oceco V-130 Conservation Regulators bring never before secured economy and dependability to the conservation of volatile products stored in cone, round, flat, lifter or expansion roof tanks. Our exclusive pressure balanced construction prevents freeze-ups and protects the tank from excessive pressure and vacuum even under the most severe weather conditions. These regulators prevent vapors from escaping at less than operating setting and **provide greater flow capacity, size for size, and pressure for pressure,** especially at low pressures, **than ever before available.** Write for Bulletin No. 522. It gives full details!

PRESSURE BALANCED CONSTRUCTION.

Tank pressures exerted on both sides of the pliable heat and cold resistant membrane keep membrane always under tension; —assuring tight seating fully up to operating setting— and positive flexing action that peels away icy formations preventing freeze-ups.



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11 ALL-IMPORTANT FACTORS WHICH DETERMINE THE VALUE AND EFFICIENCY OF PROCESSING FURNACES

✔**UNIFORM HEAT DISTRIBUTION**
MAXIMUM FUEL EFFICIENCY
PLENUM CHAMBERS FOR HAZARDOUS AREAS
SIMPLICITY OF DESIGN AND CONSTRUCTION
EXCESS DRAFT FOR HIGH OVERLOAD
EXPLOSION RESISTANT
MINIMUM GROUND SPACE
SHORT LENGTH OF LIQUID TRAVEL
ZERO AIR LEAKAGE
LOW PRESSURE DROP
LOW MAINTENANCE

✔**UNIFORM HEAT DISTRIBUTION** the most desirable heater characteristic is created in an Iso-Flow furnace by:

1. Individual burners are so spaced in relationship to the heating elements that they create a symmetrical flame pattern with relation to the tubes;

2. The metal cone at the top of the combustion chamber re-radiates to the tubes, also diverts combustion gases progressively closer to the tubes to give a uniform heat intensity at the upper portion of the combustion chamber;

3. The combustion gases, at the top of the heater, are diverted towards the walls where they recirculate from the top of the heater downward, behind and between the tubes, increasing the heat input to the rear of the heating elements by convection;

4. The recirculated gases reduce the heat intensity at the bottom of the furnace so that the heat input is the same, top and bottom.

These factors provide the completely uniform heat distribution required in heaters for the most efficient process operation.

In every case where these 11 all-important design characteristics were employed to compare one type of furnace design with another, PETROCHEM-ISOFLOW FURNACES *were proved most efficient by any comparison.*

Prove PETROCHEM-ISOFLOW FURNACES Most Efficient by Any Comparison

More than 1200 PETROCHEM-ISOFLOW FURNACES *are in operation throughout the world in the petroleum, chemical and allied industries . . . for all processes and for any duty, pressure, temperature and efficiency . . . and all Petrochem-Isoflow Furnaces are pre-eminently satisfactory.*

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UNLIMITED IN SIZE . . . CAPACITY . . . DUTY

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Reduce Down-Time Costs

with ROCKWELL-Nordstrom VALVES

The two most common valve problems that cause excessive down-time costs are seat failure (leakage) and wear. Performance records in thousands of refineries and gasoline plants prove that Rockwell-Nordstrom valves cut down-time costs because they *stay leakproof* and *wear longer in service* than any other valve. In Rockwell-Nordstrom valves, there are no exposed seats to be cut-out or corroded. Leakproof, positive shut-off is assured by pressurized lubricant sealing. Lubricant also eliminates the metal-to-metal friction that causes ordinary valves to wear out so quickly.

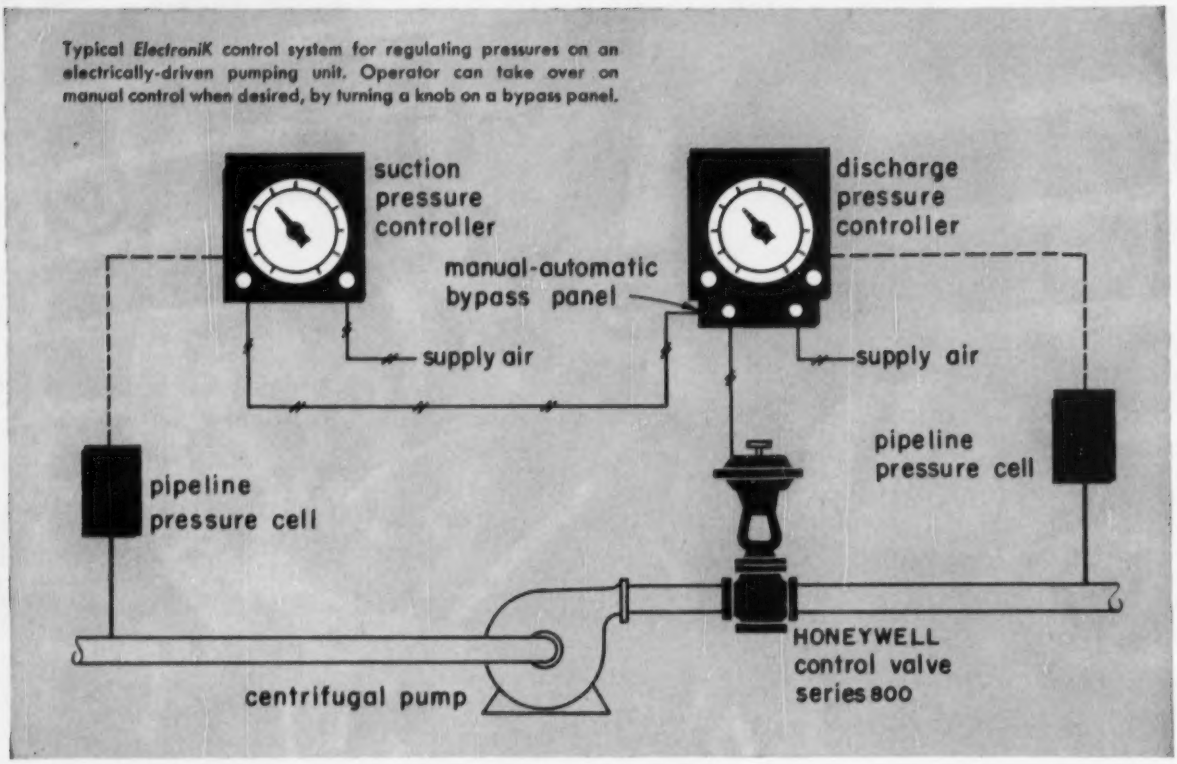
The low maintenance cost and dependability of Rockwell-Nordstrom valves is a matter of record, yet they cost no more to buy, often less, than ordinary valves. Available in a complete range of sizes and pressure ratings. Write today for more information: Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Canadian Valve Licensee: Peacock Brothers Ltd.

ROCKWELL-Nordstrom **VALVES**

Lubricant Sealed for Positive Shut-Off

40th YEAR *of lubricated plug valve leadership*



Typical *ElectroniK* control system for regulating pressures on an electrically-driven pumping unit. Operator can take over on manual control when desired, by turning a knob on a bypass panel.

Balance station pressures with fast, dependable *ElectroniK* control

For precise, dependable control of pumping pressures, put *ElectroniK* instruments to work in your pumping stations. This modern instrumentation gives the *extra* performance that spells high throughput . . . trouble-free operation.

Pressure measurement is all-electronic, instantaneous. Strain gage pressure cells, in the upstream and downstream piping, are the sensing elements. In a typical system, as diagrammed above, two *ElectroniK* instruments with *Air-O-Line* pneumatic proportional-plus-reset control actuate the Honeywell pipeline control valve. Either instrument takes over control as needed, to position the valve for desired suction and discharge pressures.

TROUBLE-FREE. No worries about dirt, dust and dampness. Maintenance saving features include such design details as totally enclosed balancing motor . . . non-clogging single air control restriction . . . sealed, liquid-filled control unit. Main components of the instrument are designed for years of service . . . can be replaced in seconds if necessary.

PRECISION . . . PLUS SENSITIVITY. Instruments are calibrated within limits of plus or minus 0.2 percent of full scale span.

For a discussion of how *ElectroniK* control can be applied in your pumping stations, call your local Honeywell sales engineer . . . he's as near as your phone.

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First in Controls

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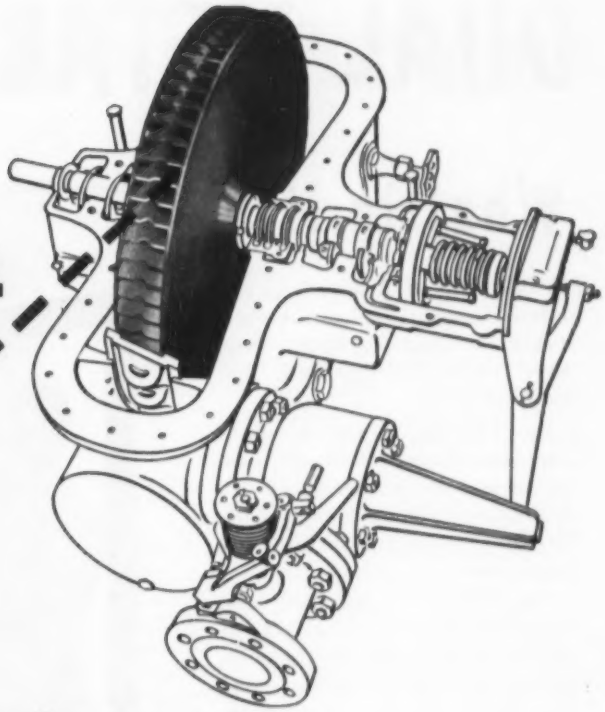
TERRY SOLID WHEEL



..."trade mark" of a trouble-free turbine

This is the rotor of a Terry solid-wheel turbine. There are a number of reasons why it has become a symbol for reliable, trouble-free operation.

First, because the wheel is a single forging, in which a series of semi-circular buckets is milled, there are no separate parts to become loose or work out.

Second, because the power-producing action of the steam takes place on the curved surfaces at the back of the buckets, blade wear is of little consequence. Wear does not materially affect horsepower or efficiency.

Third, because the steam enters the buckets in a direction at right angles to the shaft, there is no need for close axial blade clearances. The blades cannot foul. There is a one inch clearance on either side of the wheel. In addition, the blades are double rim protected.

These are only a few of the reasons why the Terry solid wheel has become a "Trade Mark" for trouble-free turbine performance. For complete details, send for a copy of bulletin S-116. No cost or obligation.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TERRY

TT-1197

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DUAL METAL··· answer to

What is it ?

To thirty-one of America's largest industries with problems of abrasion or corrosion — or both —"Dual Metal" means U. S. Pipe's Steel and Tubes Division.

Specifically, "Dual Metal" is our name for centrifugally cast cylindrical sections in which two dissimilar metals are bonded metallurgically by centrifugal force and temperature.

"Dual Metal" centrifugally cast, integrally fused combinations of two dissimilar metals are doing industry's most difficult and exacting jobs better and more economically than ever before.

Design engineers have been quick to recognize the outstanding merits of a process capable of combining the desired mechanical and chemical properties no single metal possesses.

"Dual Metal" means versatility, efficiency and economy.

Research and development play a vital and important role in the centrifugal casting of "Dual Metal" combinations. Our Pilot Foundry is devoted entirely to process and product improvement.

UNITED STATES PIPE & FOUNDRY CO.

Steel and Tubes Division

STEEL AND TUBES DIVISION U S P

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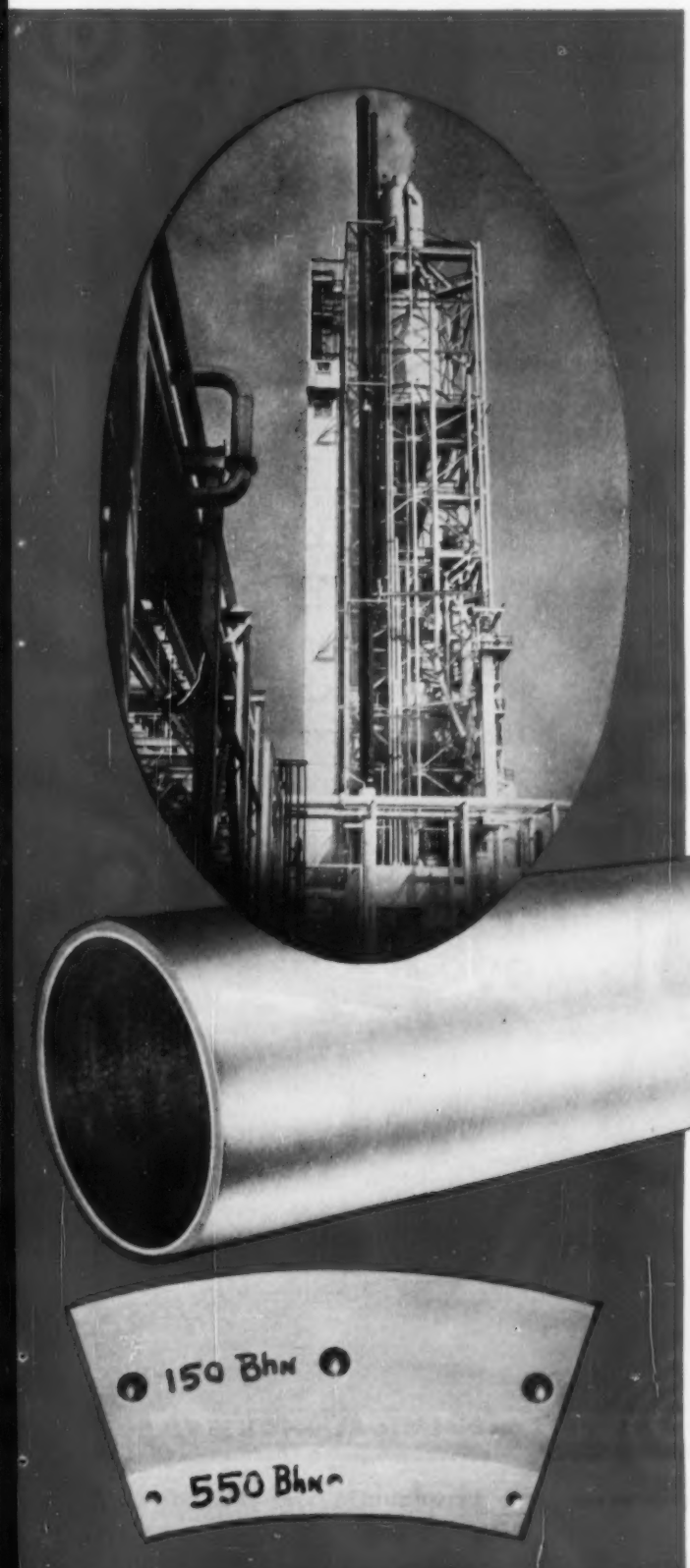
your TURNAROUND problems



"Dual Metal" solves one of the petroleum industry's most severe and costly problems — catalyst erosion of lift pipe and catalyst handling lines.

In making a "Dual Metal" lift pipe the outer shell of weldable alloy steel is poured into a rapidly rotating mold. The abrasion-resistant alloy iron core is introduced at the proper time and temperature. Result? A metallurgically bonded two-metal structure that combines the strength and weldability of low alloy steel and the superior abrasion resistance of alloy iron.

"Dual Metal" lift pipes are now in use in over 80 of the nation's leading refineries. In one typical refinery periodic examinations of high temperature catalyst pipes have indicated abrasion resistance of better than 16 to 1 over conventional steel piping. A once-troublesome bottleneck in processing has been eliminated and turnaround operations made shorter — a major saving of both time and money.

Perhaps this versatile process is the answer to your particular problem. Write today for specific literature and information on "Dual Metal's" applications for the refining industry.

"DUAL METAL" CENTRIFUGAL CASTINGS: SIZE RANGES

OUTSIDE DIAMETER: 6" to 50" WALL THICKNESS: ½" and up
LENGTH: Up to 16 ft.
TYPICAL OIL INDUSTRY APPLICATIONS: Catalyst Lift Pipe, Depressurizing Pipe, Catalyst Transfer Lines, Slush Pump Liners, Valve Nozzles, Extrusion Liners, etc.

Left. Cross-section view of dual metal piping consisting of a weldable SAE 4120 steel outer shell and a metallurgically bonded inner layer of high carbon-high chromium abrasion resisting iron. Photograph actual size. Composition of the hard inner layer:

C	Mn	P	S	Si	Cr
2.85	1.10	.009	.023	.85	29.36

Below. Photomicrograph showing the bond or fusion zone between the outer and inner metals. The mild etch required for the 4120 steel did not attack the high chromium iron. Etched — 100 diameters magnification.

Increase efficiency . . . reduce maintenance

on your heat transfer equipment . . .

Call an EFCO engineer today

Capable EFCO mechanical engineers have the diversified experience, from hundreds of jobs designed to API-ASME or ASME Codes and TEMA specifications, to anticipate your individual heat transfer problems . . . and to design job-rated heat transfer systems that will provide *guaranteed performance* at peak operating efficiency, long life with low, trouble-free maintenance.

Job-rated EFCO installations are efficiently handling pressures to 5000 psi. Equipment for your special requirements . . . minimum low to maximum high temperature services . . . can be successfully provided.

Call an experienced EFCO engineer today and get guaranteed performance from your heat transfer equipment.

EFCO

HEAT TRANSFER EQUIPMENT

ENGINEERS & FABRICATORS, Inc.

P. O. BOX 7395
HOUSTON 8, TEXAS

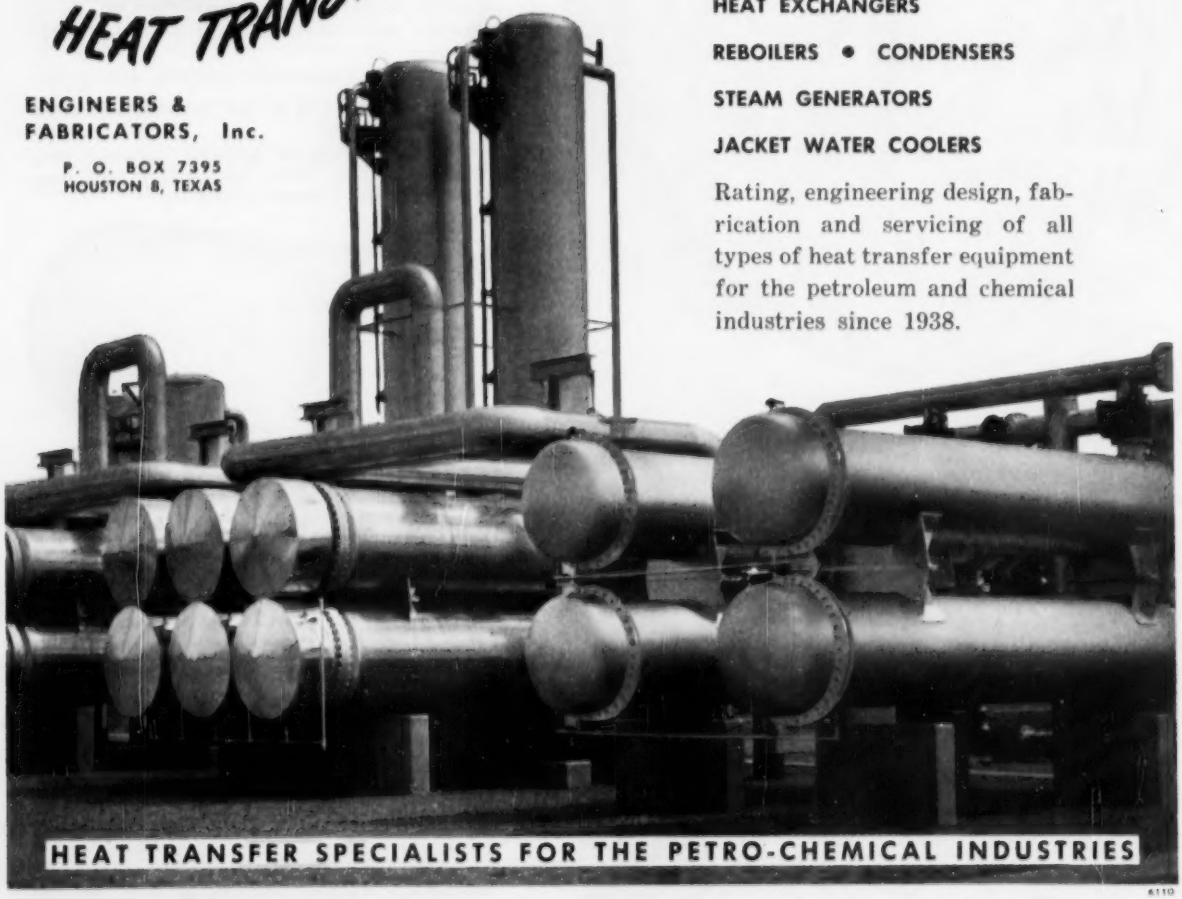
HEAT EXCHANGERS

REBOILERS • CONDENSERS

STEAM GENERATORS

JACKET WATER COOLERS

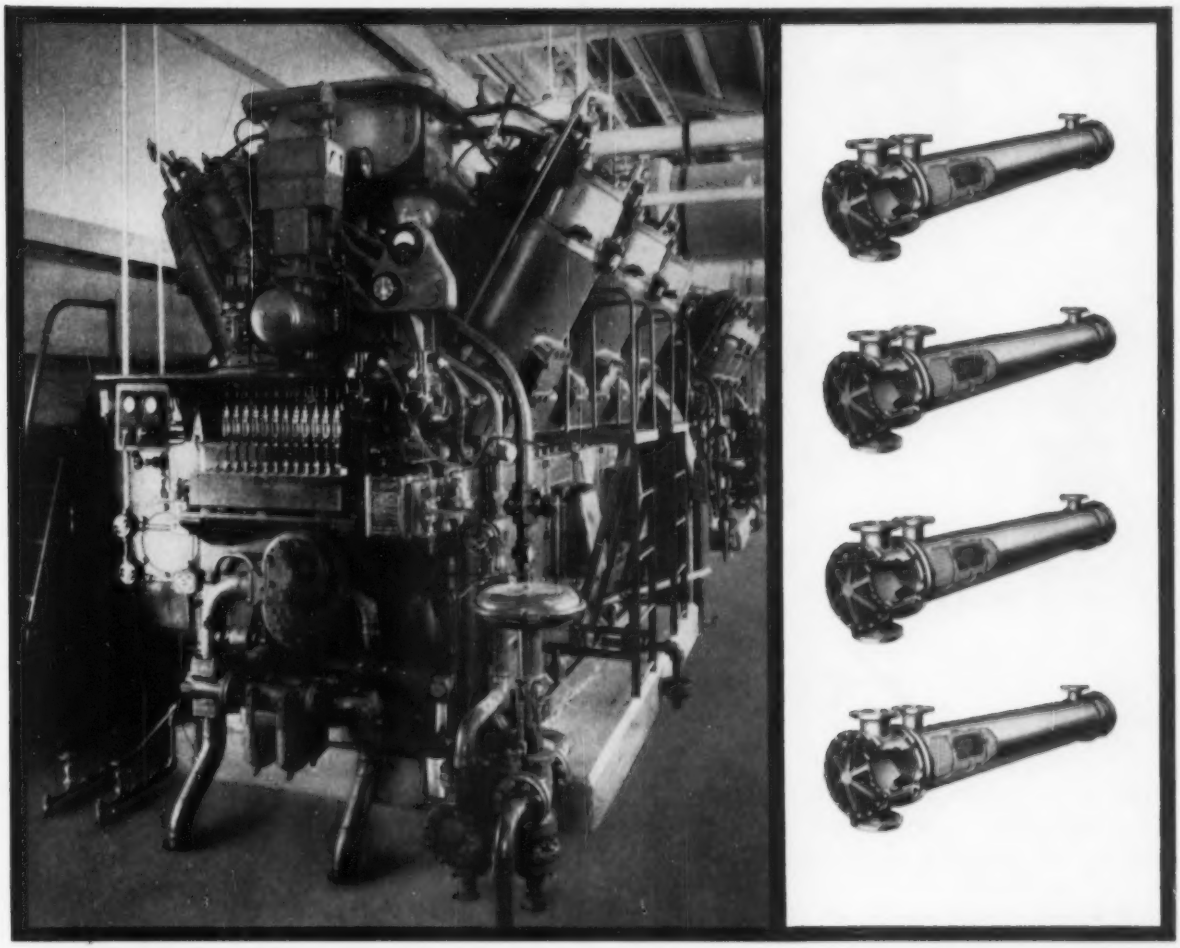
Rating, engineering design, fabrication and servicing of all types of heat transfer equipment for the petroleum and chemical industries since 1938.



HEAT TRANSFER SPECIALISTS FOR THE PETRO-CHEMICAL INDUSTRIES

6110

Extreme reliability demanded here...



Ross Exchangers safeguard lube oil in these 4 Cooper-Bessemer Compressors

Rated 660 hp at 300 rpm each, four 6-cylinder Cooper-Bessemer GMV Compressors operate in a major oil company's $15,000,000 petrochemical plant in Pennsylvania. They maintain a continuous supply of hydrogen needed to produce benzene, toulene, and high octane motor fuel.

Keeping each of these compressors running at peak operating efficiency is a Ross Exchanger. Properly cooled lube oil is supplied to vital parts at all times.

Because of their high thermal efficiency and extreme ruggedness, Ross Exchangers are given wide preference by manufacturers of numerous types and makes of machinery serving the refining and petrochemical industries: compressors, turbines, engines, blowers, reduction gears, centrifugal pumps, torque converters and fluid drives. Compact in design, these adaptable units are furnished with convenient, accessible connections for easy installation. Pre-engineered and fully standardized, they're available in a wide range of sizes to meet your needs.

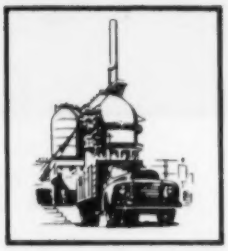
For detailed information, write for Bulletin 2.1K5. Ross Heat Exchanger Division of American-Standard, 1419 West Avenue, Buffalo 13, N. Y. In Canada: Kewanee-Ross of Canada Limited, Toronto 5, Ont.

ROSS | ROSS HEAT EXCHANGER PRODUCTS

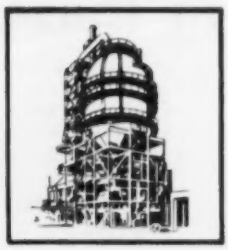
For more data on advertised products, use Readers' Service Cards, last page.

ONE SOURCE *for all Three*

ENGINEERING



MATERIALS



ERECTION SERVICE

If you are revamping or adding to the capacity of cat crackers, oil stills or heaters—you'll do better if you get a quote from Bigelow-Liptak on the refractories for the vessel or heat enclosures.

Why? Because B-L supplies all of the *three* elements which must be considered—engineering, materials, erection help.

Jobs are handled by engineers who *know* every facet of the problem at hand—men who have had years of experience with refractories and oil refinery problems. Materials used have been proven on countless installations under the most severe of abrasive or high temperature conditions. And erection is performed by a crew of men who specialize in refinery work . . . not only in the United States, but all over the world.

All in all, you can't miss. Cost? Less than you might think—particularly in the long run. Write today!

BIGELOW-LIPTAK *Corporation*

AND BIGELOW-LIPTAK EXPORT CORPORATION
2550 WEST GRAND BOULEVARD, DETROIT 8, MICHIGAN

UNIT-SUSPENDED WALLS AND ARCHES

In Canada: BIGELOW-LIPTAK OF CANADA, LTD., *Toronto, Ontario*

ATLANTA • BOSTON • BUFFALO • CHICAGO • CLEVELAND • DENVER • HOUSTON • KANSAS CITY, MO. • LOS ANGELES • MIAMI • MINNEAPOLIS • NEW YORK • PHILADELPHIA • PITTSBURGH • PORTLAND, ORE. • ST. LOUIS • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO • SEATTLE • TULSA • MONTREAL • SAULT STE. MARIE, ONT. • VANCOUVER • WINNIPEG

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MECO Integrated SERVICE

Presents

complete data for your orifice plate and meter run requirements.

SEND FOR YOUR COPY NOW!

ask for Bulletin No. P-100 (Meter Runs)
Bulletin No. P-101 (Orifice Plates)

MECO
MAINTENANCE
Mechanical CORPORATION
SUBSIDIARY OF
MAINTENANCE ENGINEERING CORPORATION

ON COVERING THE WORLD . . .

A 50 YEAR EXPERIENCE

From the early days of "Boiler Covering" Newalls have been foremost in the development of industrial insulation techniques.

In almost every country, meeting all types of climatic and working conditions, are installations on which Newalls' Insulation has for many years given maximum heat conservation and temperature control.

With an international contracting organisation and time-proved materials including Newalls (Reg'd. Brand) 85% Magnesia, Nicosil, Newtempheit and Amosite Asbestos, Newalls provide an insulation service ensuring peak operating efficiency in Oil Refineries and Petro-Chemical plants.

Newalls
(REG'D BRAND)

LEADERS IN REFINERY INSULATION

NEWALLS INSULATION CO. LTD. *Head Office:* WASHINGTON, CO. DURHAM, ENGLAND
A member of the TURNER & NEWALL ORGANISATION
Agents and vendors in most markets abroad

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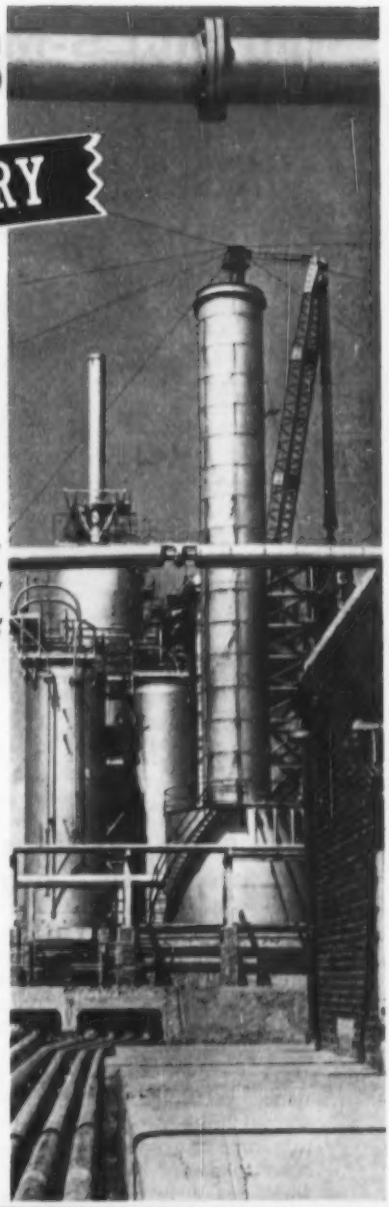
PIPE INSTALLATIONS

FOR THE PETROLEUM INDUSTRY



Superior plant is the Potent Agent in achieving economical production. Petroleum plants require pipes and fittings that will give efficient service allied to well planned layout.

Shaw-Petrie and Clyde Tube Forgings Limited, manufacture, fabricate, and erect, to the highest specification, a complete range of pipe-work and Seamless Steel and Alloy Butt Welding Fittings.

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CANADIAN CLYDE TUBE FORGINGS
P.O. BOX 278 WESTON ONTARIO

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SHAW-PETRIE Telegrams "PIPELINE, GLASGOW" CLYDE TUBE FORGINGS Telegrams "TUBEFORGE, GLASGOW"

LONDON OFFICE, ST. STEPHEN'S HOUSE, VICTORIA EMBANKMENT, SW1. Phone TRAFALGAR 5511-4. Grams TUBEFORGE, PARL, LONDON

AND AT SOUTH SHIELDS, LIVERPOOL AND BELFAST

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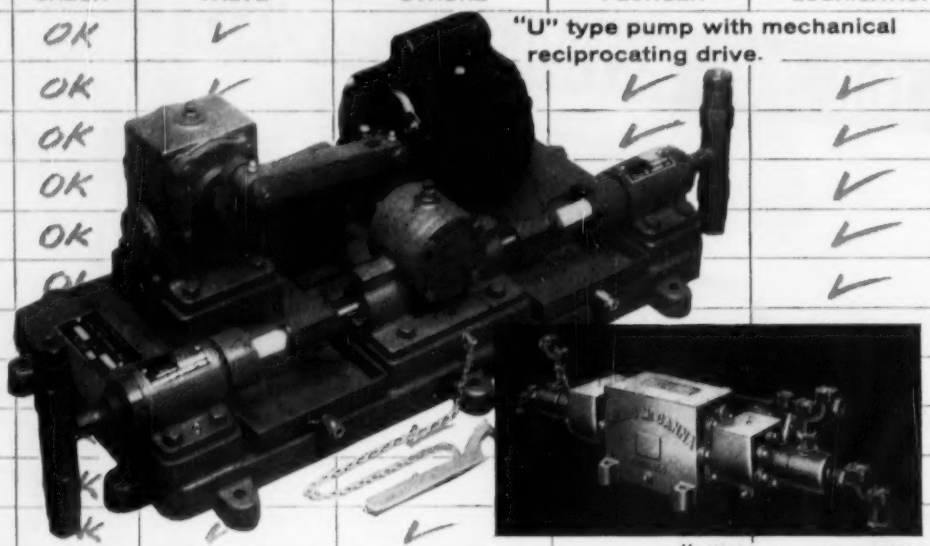
Why the FIRST COST is the LAST COST with HILLS-McCANNA METERING PUMPS

PUMP MAINTENANCE REPORT

MONTH	CHECK	VALVE	STROKE	PLUNGER	LUBRICATION
JANUARY	OK	✓			
FEBRUARY	OK	✓		✓	✓
MARCH	OK			✓	✓
APRIL	OK				✓
MAY	OK				✓
JUNE	OK				✓
JULY					
AUGUST					
SEPTEMBER					
OCTOBER	OK				
NOVEMBER	OK	✓	✓		
DECEMBER	OK	✓	✓	✓	



"U" type pump with mechanical reciprocating drive.

"K" type pump with hydraulic drive.

HILLS-McCANNA dependability pays off in lower maintenance . . . longer life . . . greater accuracy . . . cost-saving versatility

Maintenance reports from the leaders in many different industries prove the low-cost operation of Hills-McCanna metering and proportioning pumps . . . tell why these pumps are specified for installations requiring the finest equipment. Part replacement is remarkably low because there are few points of wear. Routine maintenance is simple and economical thanks to special Hills-McCanna features, such as separate interchangeable check valves and easy, precise stroke adjustment (even while in operation when desired). Working parts are completely enclosed to keep them dirt-free. All U Type pump bodies are interchangeable in the housing for quick convertibility. Straight reciprocal drive eliminates bushing replacement. And, you'll find Hills-McCanna pumps mighty easy to install.

If you must continuously meter or proportion small volume flows with great accuracy, you'll want to consider the "U" type pump—available in 1, 2, 3 and 4 feed units. The "K" type pump —also available in 1, 2, 3 or 4 feed units—will meet your larger flow requirements.

Hills-McCanna can furnish a pump to meet *every* type of installation . . . with a wide choice of corrosion, wear and abrasion-resistant liquid ends . . . in capacities and pressures for every need.

Write for full facts now. You'll be dollars ahead tomorrow by investigating today!

A dependable NEW HEART to put NEW LIFE into your chemical metering system!

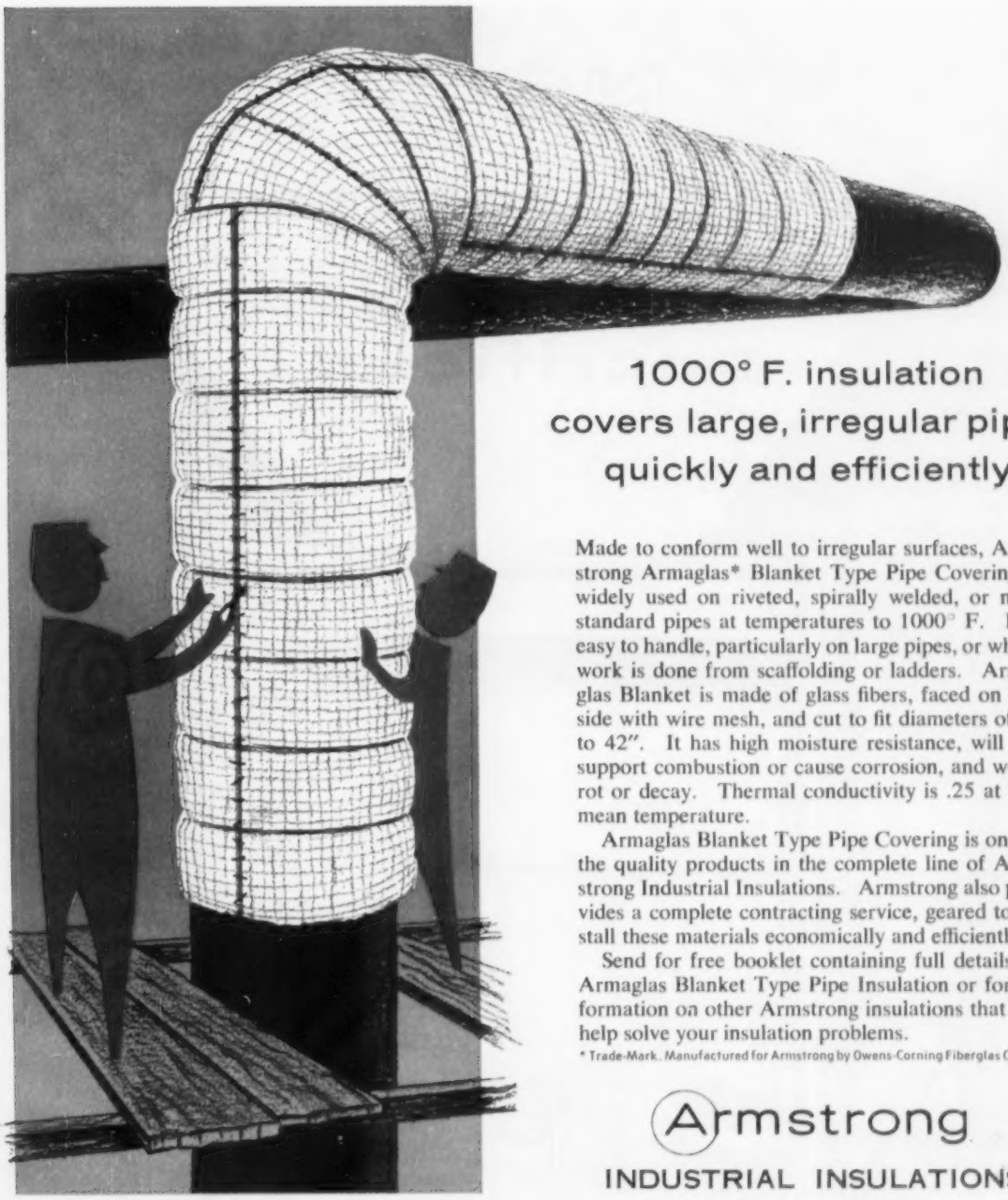
HILLS-McCANNA COMPANY

3025 N. Western Avenue, Chicago 18, Illinois

metering and proportioning pumps

also manufacturers of: FORCE FEED LUBRICATORS • DIAPHRAGM VALVES
MAGNESIUM ALLOY SAND CASTINGS

For more data on advertised products, use Readers' Service Cards, last page.



1000° F. insulation covers large, irregular pipes quickly and efficiently

Made to conform well to irregular surfaces, Armstrong Armaglas* Blanket Type Pipe Covering is widely used on riveted, spirally welded, or non-standard pipes at temperatures to 1000° F. It is easy to handle, particularly on large pipes, or where work is done from scaffolding or ladders. Armaglas Blanket is made of glass fibers, faced on one side with wire mesh, and cut to fit diameters of 3″ to 42″. It has high moisture resistance, will not support combustion or cause corrosion, and won't rot or decay. Thermal conductivity is .25 at 75° mean temperature.

Armaglas Blanket Type Pipe Covering is one of the quality products in the complete line of Armstrong Industrial Insulations. Armstrong also provides a complete contracting service, geared to install these materials economically and efficiently.

Send for free booklet containing full details on Armaglas Blanket Type Pipe Insulation or for information on other Armstrong insulations that can help solve your insulation problems.

* Trade-Mark. Manufactured for Armstrong by Owens-Corning Fiberglas Corp.

Armstrong

INDUSTRIAL INSULATIONS

☐ Armstrong Armaglas Insulations for Pipes, Tanks, and Vessels

☐ Armstrong Insulcolor®, Weatherproof Coating in Eight Colors

☐ Armstrong Armatemp* Blocks, Blankets, and Cements

*TRADE-MARK

☐ Armstrong LT Cork Covering, a New Type Cold Line Insulation

Armstrong Cork Company
2007 Ream Ave.
Lancaster, Penna.

Please send me the free booklets checked. ☐

Please have an Armstrong representative call. ☐

Name .....

Position .....

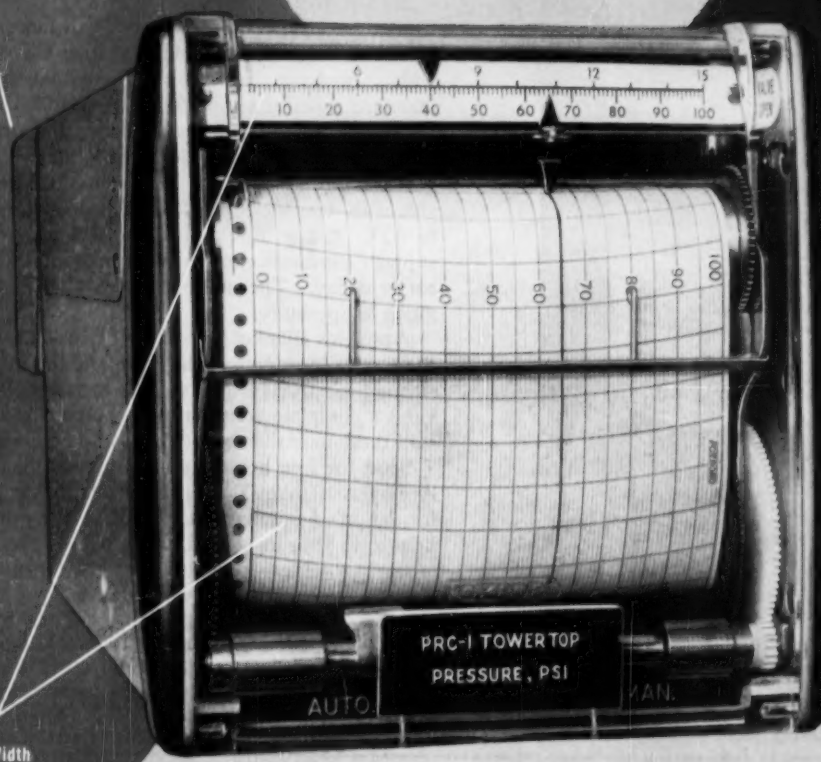
Company .....

Address .....

City ..... Zone .... State .....

NOW...

compactness with nothing sacrificed!



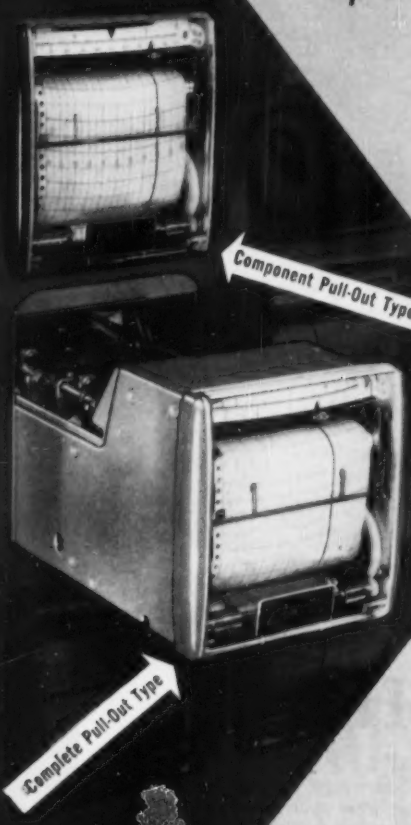
Models to Meet All Your Specifications

In all the following CONSOTROL instruments, recorder and indicator units can be easily converted in field.

- Recording Control Station with automatic/manual transfer
- Recording Control Station with manual loading only
- Recorder — single or two pen
- Indicating Control Station with automatic/manual transfer
- Indicating Control Station with manual loading only
- Indicator — single or two pointer

CONSOTROL

small-case panel instruments



Here's the "tops" in centralized recording and control efficiency! CONSOTROL* Instruments require the minimum of valuable panel space, yet provide unsurpassed operator convenience, visual accuracy, and ease of maintenance . . . maintain the highest standards of precision and dependability. For example: the simple CONSOTROL method of switching from automatic to manual control requires no memory or extra operations . . . never "bumps" the process. All CONSOTROL charts and scales are full 4-inch width for greatest visibility . . . highest accuracy. When it comes to servicing, there's plenty of "finger room" . . . all parts are uncrowded and easily removable. And just compare inking requirements with other designs. CONSOTROL needs ink filling only once or twice a year! These are only a few of CONSOTROL's advanced design features — available in both fixed-mounting and full pull-out type instruments. Get the complete story. Write for Bulletin 13-18. The Foxboro Company, 747 Neponset Avenue, Foxboro, Mass., U.S.A.

*Reg. U.S. Pat. Off.

FOXBORO

REG. U.S. PAT. OFF.

Consotrol Process Control

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

For You

Catalyst "Know-How"

What makes one catalyst superior to another? Often it is the unseen ingredient, "know-how". Davison's long experience in successful catalyst production gives you this all-important element.

Davison, the first commercial producer of synthetic petroleum cracking catalysts, operates a modern plant for the sole purpose of producing specialty catalysts to aid industrial chemical progress. These catalysts can be custom made to your specifications. We guard your "know-how" as carefully as we do our own. They are made in many forms including granular, pelleted, powdered, spherical, extruded and include many supports and active agents.

Put Davison's "know-how" to work on your problem. No matter what your catalyst requirements are, it will pay you to discuss them with the Davison Field Service Engineer. A free booklet on Davison dependable catalysts is available on request.

DAVISON CHEMICAL COMPANY

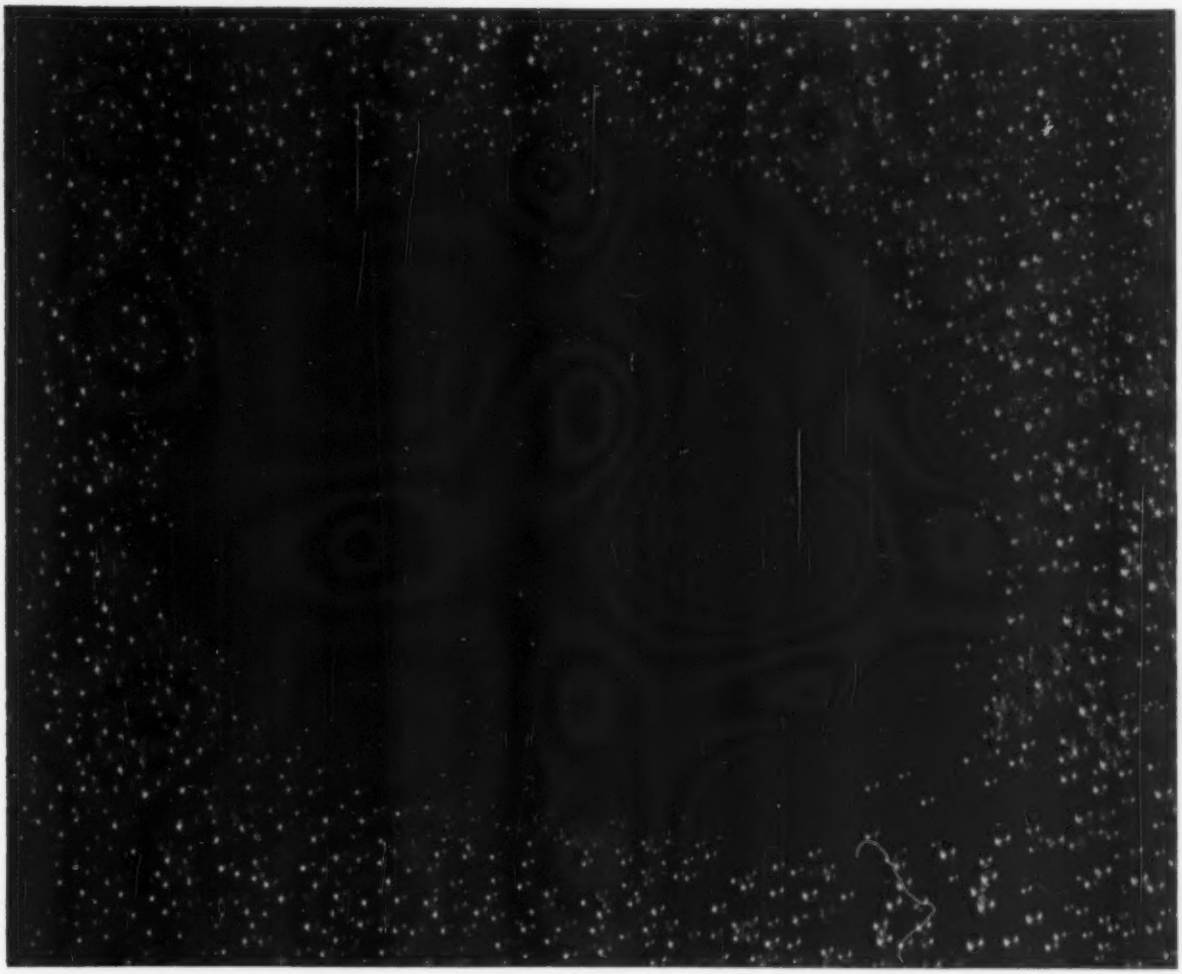
Division of W. R. Grace & Co.

Baltimore 3, Maryland

Sales Offices: Chicago, Illinois; Houston, Texas; New York, New York; Baltimore, Maryland

In Canada: Davison Chemical Company Ltd., Toronto

Producers of: Catalysts, Inorganic Acids, Superphosphates, Triple Superphosphates, Phosphate Rock, Silica Gels and Silicofluorides. Sole Producers of DAVCO® Granulated Fertilizer.



An Inside-Out View

CORROSION INHIBITOR AT WORK

Here's an external view of what takes place internally in refinery equipment. This photograph shows a piece of mild steel. The center has been treated with Polyrad. The entire piece of steel then was immersed in an acidic environment. The tiny bubbles of hydrogen show the beginning of corrosion. But the center portion remains a safety island—thanks to Polyrad.

This photographic impression bears out what most refinery operators already know—that Polyrad is an effective inhibitor. It will economically reduce corrosive damage with an average treatment of about 1 quart of Polyrad per 1,000 barrels of fluid.

Polyrad's powerful detergent action also serves to loosen organic and inorganic deposits, allowing them to be removed in the fluid stream.

All around the refinery, Polyrad can help maintain throughput, increase heat transfer, reduce metal loss, and cut down-time for maintenance. A Hercules technical representative will be glad to explain how Polyrad can be used to combat your specific corrosion problem.

NA56-4

Pine Chemicals Division, Naval Stores Department

HERCULES POWDER COMPANY

INCORPORATED

976 Market St., Wilmington 99, Del.

POLYRAD®

FILMING AMINE INHIBITOR

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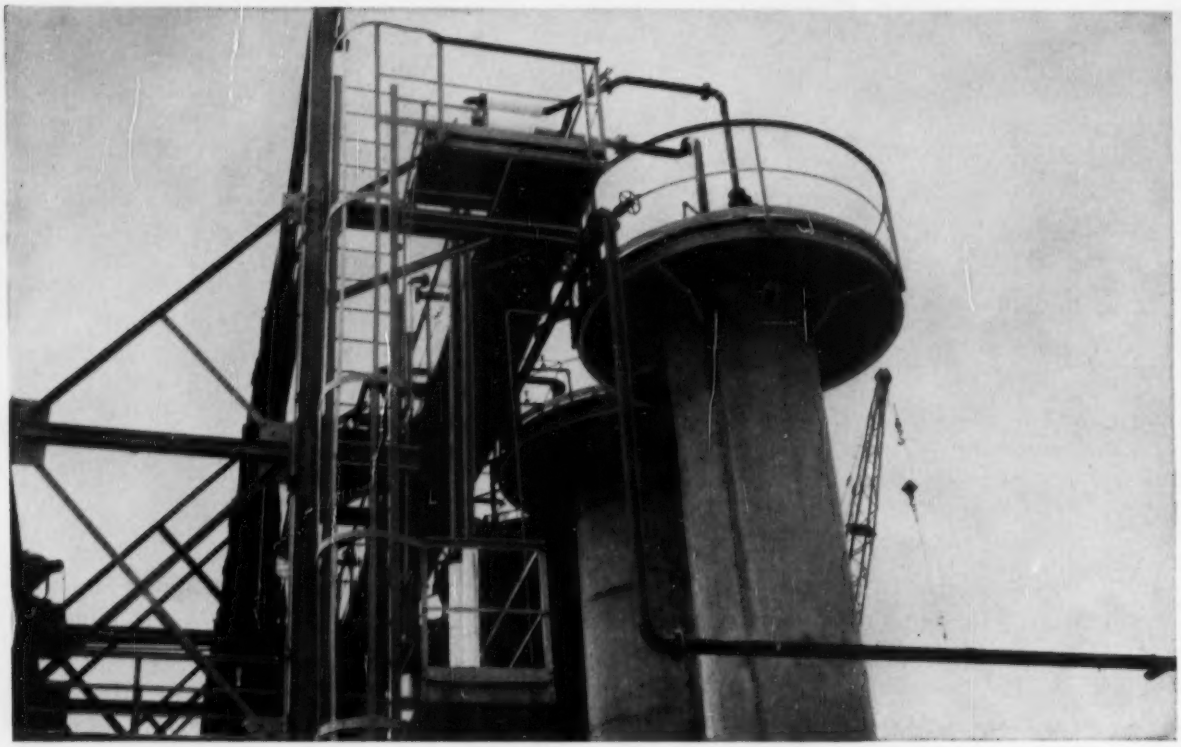


HASTELLOY Alloy B Handles Hydrogen Chloride at 1000 deg. F

PROBLEM:

Handling highly-reactive hydrogen chloride gas containing water at 1000 deg. F at the top of chlorine burner towers used in making hydrochloric acid. Chlorine is burned inside the towers in a hydrogen atmosphere. Ordinary materials used at the top of these burners would last only a few weeks at best.

REMEDY:

Burner covers are made of HASTELLOY alloy B. The hot gas is channelled through a cast cross, piping, and valves made of alloy B.

RESULT:

30 to 40 times longer service is given by the parts of HASTELLOY alloy B. Down time is cut to a minimum and production is increased.

HASTELLOY alloy B is resistant to hydrogen chloride gas at high temperatures, wet or dry. It is also highly resistant to hydrochloric acid in all concentrations and at temperatures up to the boiling point. The alloy is readily fabricated and has strength properties comparable to high-alloy steel. For a copy of a booklet describing HASTELLOY alloys, get in touch with the nearest Haynes Stellite Company office.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" and "Hastelloy" are registered trade-marks of Union Carbide and Carbon Corporation

AUTHENTIC
Western Heat Exchanger
CASE HISTORY

CUSTOMER: *Spencer Chemical Company*

WESTERN'S *Speed and Flexibility*

PUTS SPENCER PLANT BACK *ON STREAM*

IN JUST 47 HOURS!

SCHEDULE OF OPERATIONS
MARCH 29-30-31

At Spencer Chemical Company's Jayhawk Works at Galena, Kansas, on March 29, 1956, oil was bled into a compressor air aftercooler, through a valve failure, causing a fire in the shell side of a heat exchanger, completely melting out the admiralty extended surface in the air aftercooler. THIS RESULTED IN A LOSS OF 130 TONS OF NITRIC ACID PER DAY!!

The ability to redesign a prime surface exchanger to handle the heat load originally handled by a special extended surface bundle, and to fabricate from stock materials in thirty hours, emphasizes the importance of Western's speed and flexibility to our Engineering and Operating clientele.

Western merits *your* consideration on present and future heat transfer requirements.

5:40 p.m., Mar. 29

Call from Spencer Kansas City office, requesting retubing of an existing bundle of unusual design.

8:30 p.m., Mar. 29

Following engineering meetings on problem, Western engineer travels to Spencer plant, inspects damage, sketches existing tube sheets and other details affecting bundle fit; returns to Tulsa same night.

7:30 a.m., Mar. 30

Based on heat load, air quantities and flow, new rating is performed, permitting bare tube, prime surface bundle to do job of original specialized extended surface tubes, staying within pressure drop limitations on shell side of unit.

10:00 a.m., Mar. 30

Drafting Department starts on tube sheet layouts, from completely rated unit. Complete bundle drawings in hands of Shop by noon.

12:00 noon, Mar. 30

Stationary tube sheet, fixed tube and baffles drilled on three presses, with crew cutting 600 ¾" x 16 BWG x 20' admiralty tubes to 17' 2" lengths.

9:00 p.m., Mar. 30

Bundle completely assembled, electronic torque controlled rolling of 600 tubes at stationary and floating tube sheets begun. Completed, crated, and shipped by midnight.

4:15 p.m., Mar. 31

Spencer plant back "on stream," having received bundle at 5:30 a.m., completely installed by 10:00 a.m.

WESTERN
HEAT EXCHANGERS

WESTERN SUPPLY COMPANY
P. O. BOX 1888 • TULSA, OKLAHOMA

HUDSON-RUSH COMPANY — 753 Gladstone Blvd., Shreveport, La.
130 Casa Linda Plaza, Dallas, 18, Tex.
P. O. Box 3151, Amarillo, Tex.

PROCESS INSTRUMENTS & EQUIPMENT CO. — North Bldg., Charleston, W. Va.

H. W. SEVERANCE — 2416 Frankfort Ave., Louisville, Ky.

CHASE BRASS & COPPER CO. **WATERBURY 20, CONN.**

Dept. PR-756

Gentlemen:

PLEASE SEND ME A FREE COPY of your descriptive 54-page manual titled: CHASE CONDENSER AND HEAT EXCHANGER TUBES. I understand it contains the following material:

A. An up-to-date discussion of corrosion problems that will help me select the alloy tube best suited to meet my requirements.

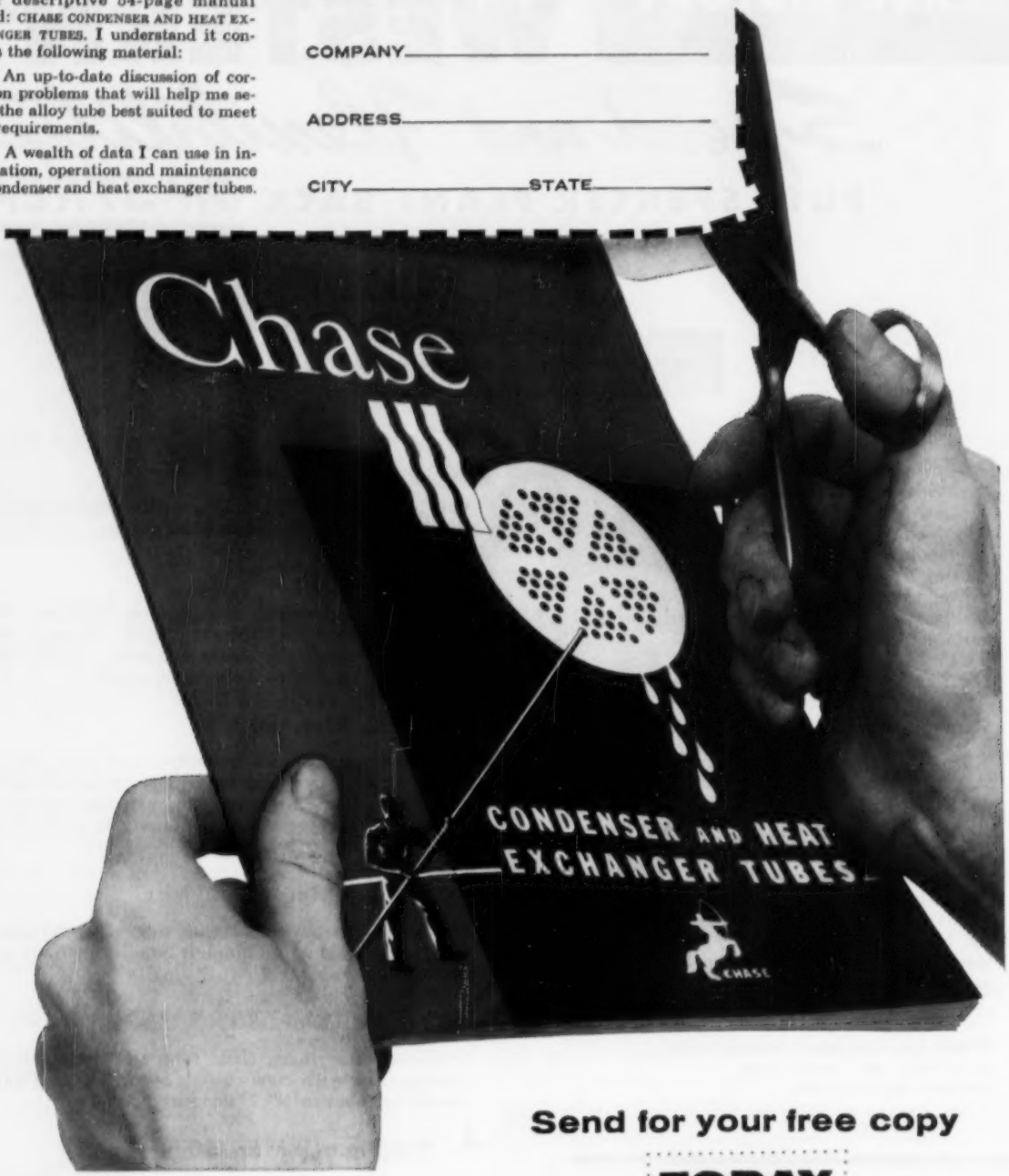
B. A wealth of data I can use in installation, operation and maintenance of condenser and heat exchanger tubes.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____



Send for your free copy

TODAY

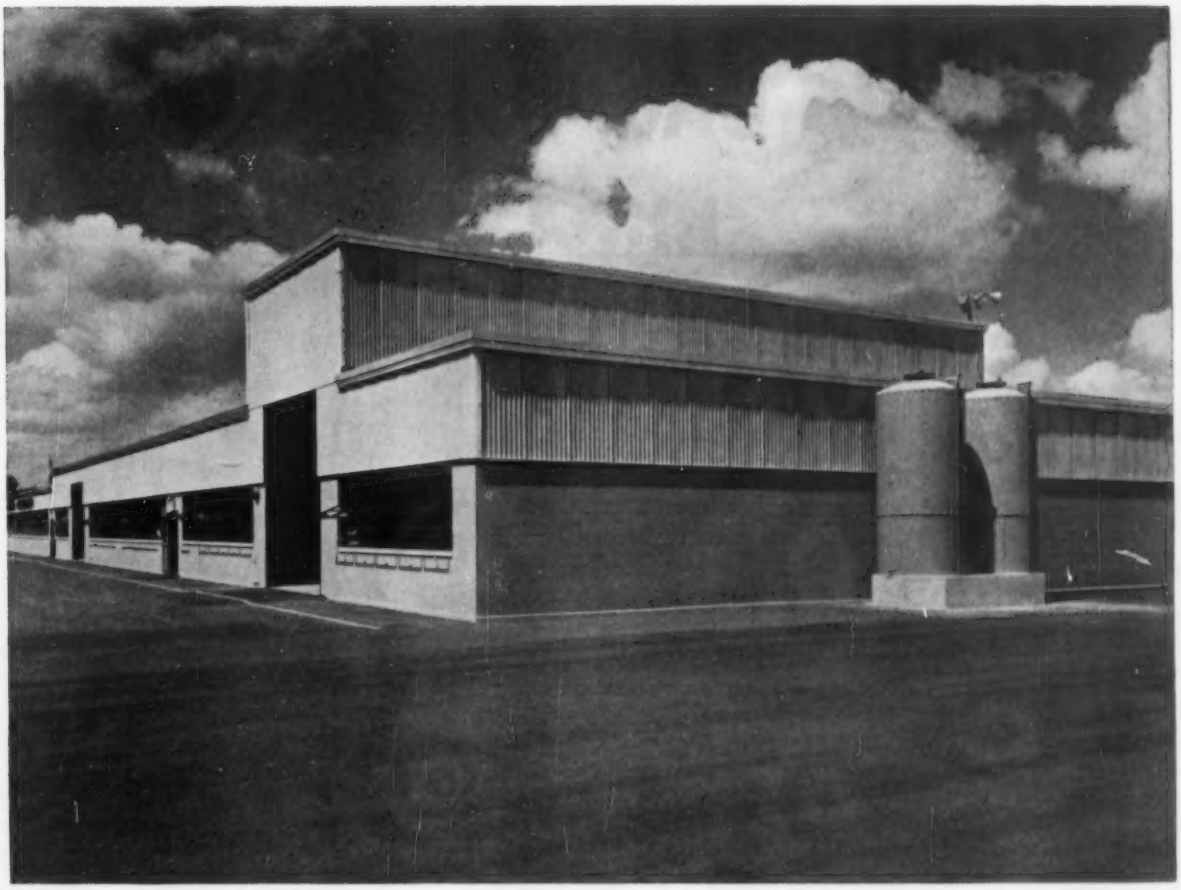
Chase

BRASS & COPPER CO.

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

The Nation's Headquarters for Brass, Copper and Stainless Steel

Atlanta	Chicago	Denver	Indianapolis	Minneapolis	Philadelphia
Baltimore	Cincinnati	Detroit	Kansas City, Mo.	Newark	Pittsburgh
Boston	Cleveland	Grand Rapids	Los Angeles	New Orleans	Providence
Charlotte	Dallas	Houston	Milwaukee	New York	Rochester
St. Louis	San Francisco	Seattle	Waterbury		



K&M Corrugated Asbestos Sheets, used as siding on the Operations Center of a southeastern utility company, complement the clean, modern lines of the building. These sheets are also used on a pitched roof, not shown in the photograph. Engineering and supervision of construction: Stone and Webster Engineering Corporation. Applicator: Whatley Roofing and Sheet Metal Works, Tampa, Florida.

Attractive, weather-proof, fire-proof, maintenance-free
K&M Corrugated Asbestos

Building a new plant? Modernizing your present one? In either case, you'll gain important cost and other advantages with K&M Corrugated Asbestos-Cement Sheets. They cannot burn, can't rot or corrode—withstand the ravages of time and weather year after year. Because K&M Corrugated Asbestos-Cement Sheets rarely require maintenance, *never* need protective painting, their upkeep is held to the barest minimum.

Easy to apply. These corrugated sheets offer big savings in application costs. They go on quickly, are easily sawed, drilled, and fitted on the job.

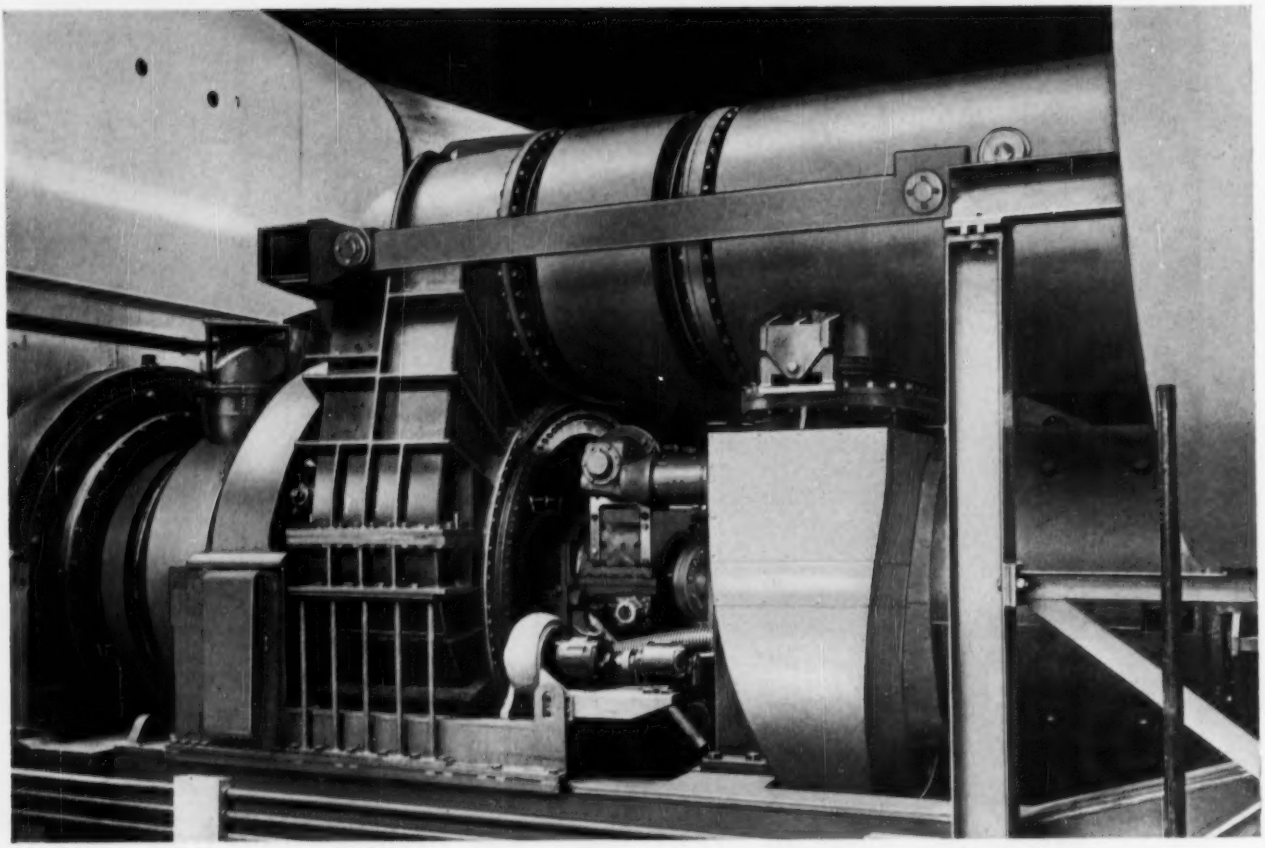
Write for complete details on K&M Corrugated Asbestos Roofing and Siding.

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

K&M best in asbestos®

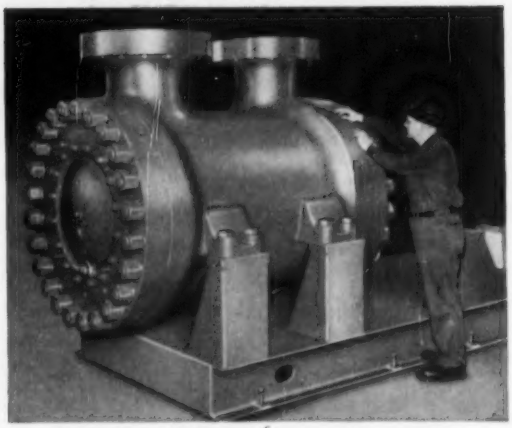
For more data on advertised products, use Readers' Service Cards, last page.

GAS TURBINES



Clark 8500 BHP Gas Turbine for centrifugal compressor, generator or pump drive

Clark Barrel Type Centrifugal Compressors for extremely high pressures



CLARK®

GAS TURBINES
CENTRIFUGAL COMPRESSORS

For more data on advertised products, use Readers' Service Cards, last page.

CENTRIFUGAL COMPRESSORS
Only CLARK builds both!

Now you can get centrifugal compressors and modern gas turbines to drive them *exclusively* from one manufacturer . . . Clark.

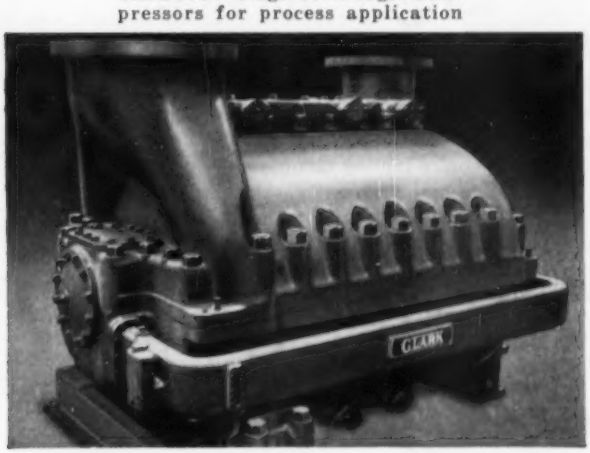
In addition to saving money and headaches, you'll get proved, matched-performance "packages" specifically designed for continuous trouble-free service.

Whether you have a million or a billion cubic feet of air or gas per day to handle at pressures of up to 4500 pounds per square inch, there is a Clark centrifugal compressor and in most cases a matching Clark gas turbine to drive it.

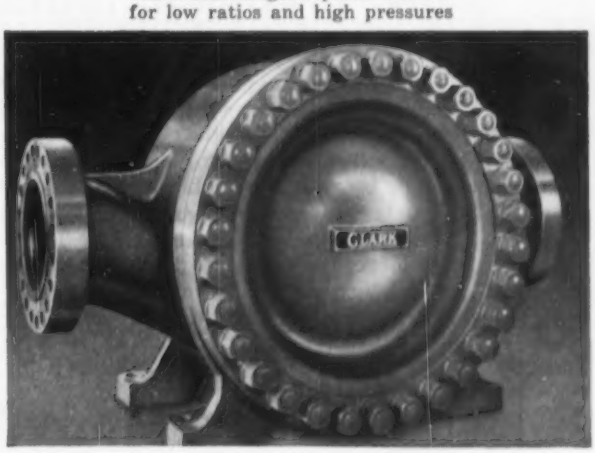
Your nearest Clark representative will be pleased to give you all the facts.

CLARK BROS. CO., OLEAN, N. Y.
One of the Dresser Industries
Offices in Principal Cities throughout the World

Clark Multi-Stage Centrifugal Compressors for process application

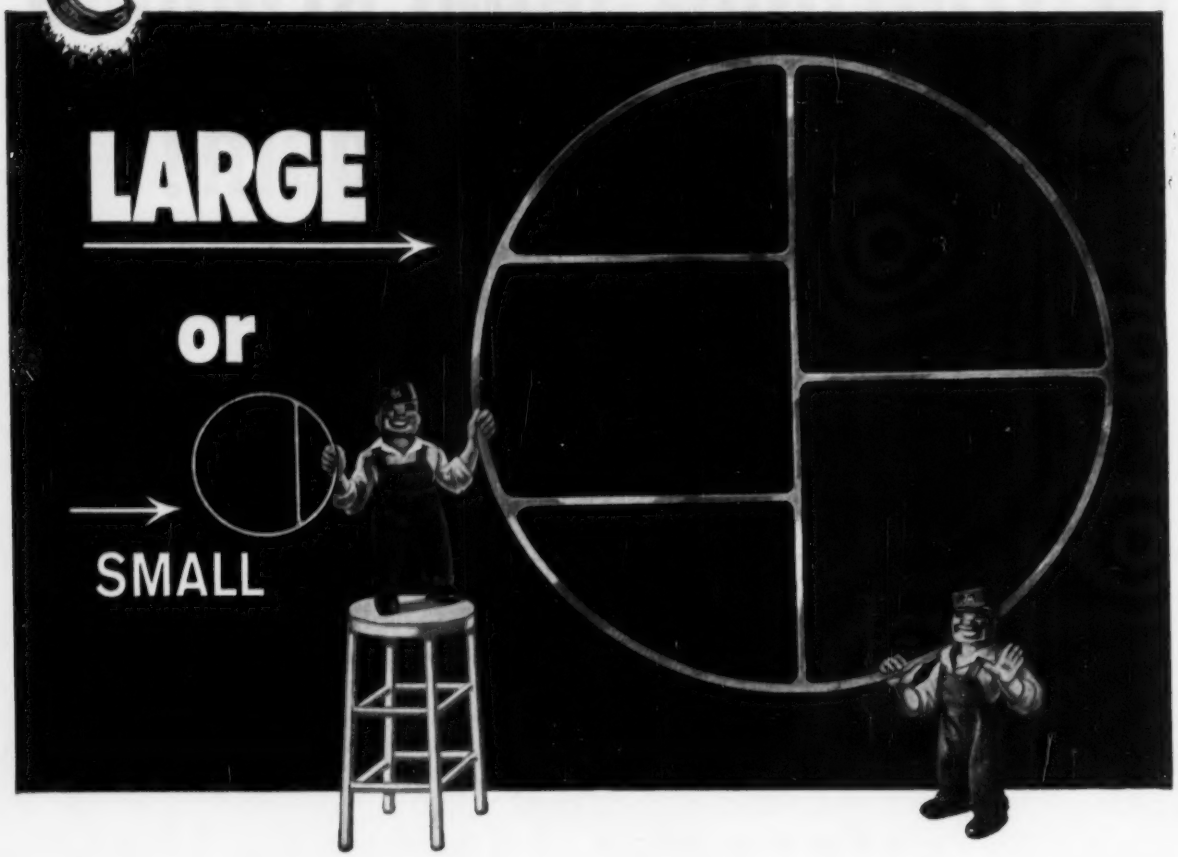


Clark Centrifugal Pipeline Booster for low ratios and high pressures



For more data on advertised products, use Readers' Service Cards, last page.

Hand-tailored to any size you need...



...Goetze Heat Exchanger Gaskets are precision-made for longer service

Whether your requirements call for heat exchanger gaskets larger than 100" in diameter, or smaller than 10", you can get the exact size you want . . . hand-tailored to the shape you need . . . simply by specifying "Johns-Manville Goetze."

And because they're *precision-made*, you'll find these better gaskets provide the effective sealing and longer life that make them actually cost less in the long run. Each gasket is carefully constructed in every detail to assure accuracy of fit . . . to provide ample lap widths and uniform rib widths . . . and to prevent trouble-making wrinkles or cracks on the corners.

If you're having trouble with persistent joint leakage and frequent gasket replacements, find out how little it costs to have Goetze Heat Exchanger Gaskets tailored to your requirements. Your blueprint or template will bring a prompt estimate. Address Johns-Manville, Box 60, New York 16, New York.

Johns-Manville *Goetze* GASKETS

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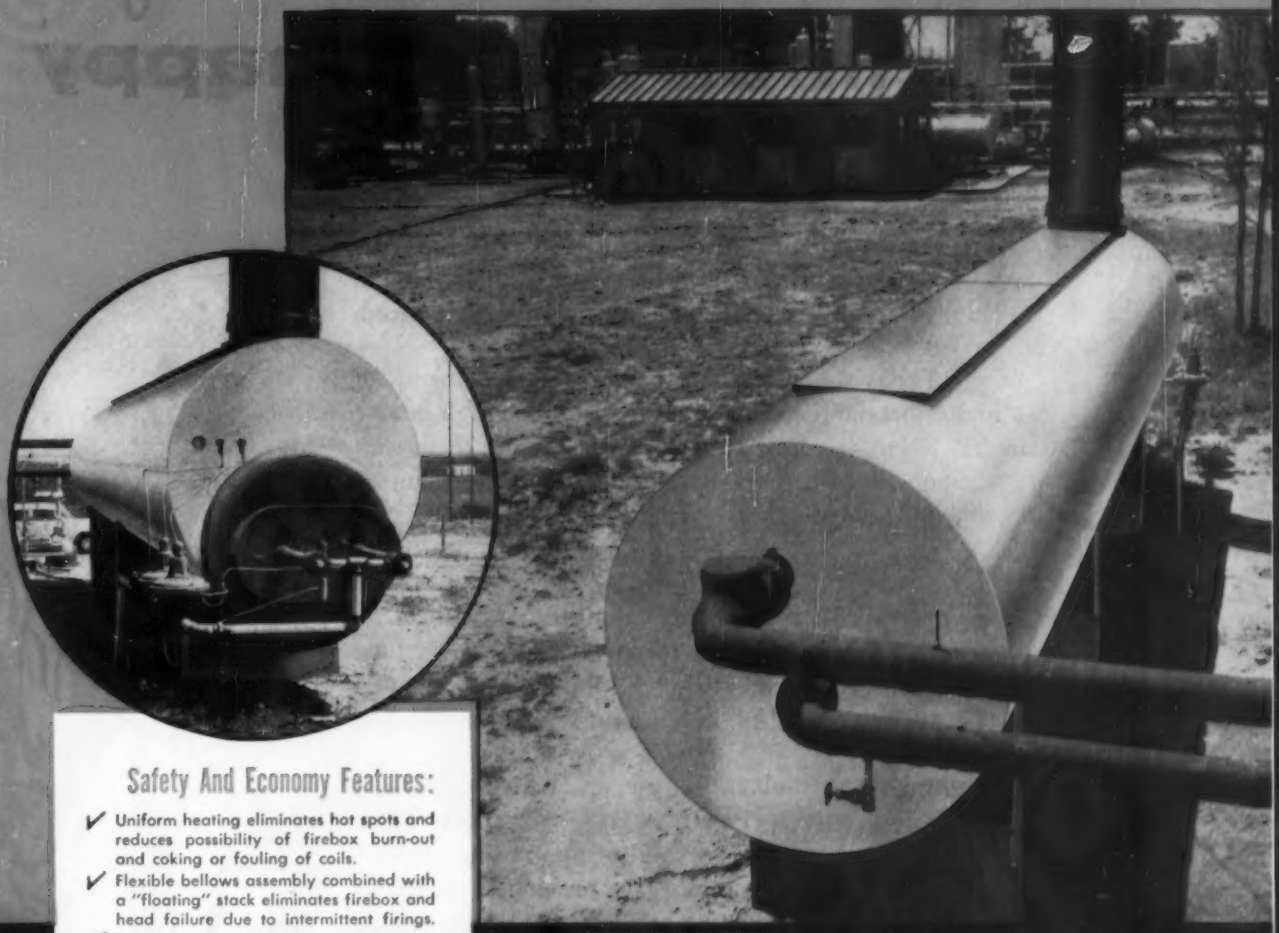
New BS&B Salt Bath Heater

Provides Safest Method Of High Temperature Heating!



Safety And Economy Features:

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- ✔ Flexible bellows assembly combined with a "floating" stack eliminates firebox and head failure due to intermittent firings.
- ✔ Heat transfer salt bath operates at atmospheric pressure, and therefore cannot cause vessel rupture.
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- ✔ Ample space for the salt has been provided to prevent "boiling over". Salt requirements have been minimized for greater economy.
- ✔ Reliable BS&B heater controls with dual temperature controls are standard equipment. BS&B pilot light permits either snap-acting or throttling burner controls with minimum possibility of pilot failure.

...Provides Uniform Heating Up To 800°F.!

BS&B now offers a complete new line of Salt Bath Heaters with capacities ranging from 75,000 to 6,000,000 BTU/Hr. A wide selection of coils of various sizes and pressure ratings makes them adaptable to virtually any application requiring uniform heating up to 800° F.

These units are ideally suited for the heating of oil, paraffins and gas (as in the reactivation of dry desiccant dehydrators). They may also be used in fractionater reboiler service and other low pressure drop applications.

For complete details on the new BS&B Salt Bath Heater, contact your nearest BS&B Representative, or write to...

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IN THE *Octane Derby*...
no refiner will be happy .

Like it or not, every refiner today must look to his octanes. As a matter of competitive survival it is vital that your refining processes provide maximum quality to every gallon of gasoline produced.

Today's, and tomorrow's, increasing demand for higher octane fuels cannot be met by one high octane stream. No matter how good that one stream, there isn't enough of it to bring pool octanes up to required levels; and the higher you raise the quality of that stream the less you'll get.

This is why UOP has consistently devoted much of its research to the over-all development of more practical refining methods, the broad goal of helping you get the most out of every drop of oil that passes through your refinery.

An important result of this work is Universal's latest refining process—PENEX. This new process offers an efficient and practical method of up-grading pentane and hexane fractions, the previously neglected components that can so adversely affect the octane ratings of your pool gasoline.

In the race for higher octanes, you cannot afford to forget that the goal is to improve the general quality of your pool gasolines. PENEX offers a means of accomplishing this practically and economically. It should be given immediate consideration in your planning.

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Forty Years Of Leadership In Petroleum Refining Technology

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PENEX

TRADEMARK

A new isomerization process for up-grading pentane and hexane fractions

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3 (for that emergency extra)

Don't be caught in a gauge glass shutdown.

Order 2 spares for every gauge glass you have. Then you have a ready replacement for routine use. The spare *spare* you use to hurry back into production should a glass go accidentally.

Protect yourself from replacement delay. Look ahead and avoid emergency.

Remember: "ONE FOR THE GAUGE AND TWO FOR THE SHELF." And always specify hard-to-break CORNING®, PYREX® and MACBETH® gauge glasses. It's the economical way.

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Normal Conditions (Up to 100 p.s.i.)	CORNING brand standard gauge glasses
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Extra visibility	PYREX brand red-line gauge glasses
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Equations Questioned

To the Editor:

Dr. Van Ness is to be commended for his excellent article, "Thermodynamics for Process Evaluation" which was presented in the January issue. Such papers open new horizons for the chemical engineer. They show him the way of efficiently applying his theoretical knowledge to the analysis of industrial processes.

I appreciate very much the effort of the author in the above mentioned article. However, the validity of Equations 9, 13, 15 and 16 is to be argued. In Equation 9, the author concludes that:

$$dS_{surr} = \frac{dQ_{surr}}{To} = -\frac{dQ}{To}$$

Where $dQ = -dQ_{surr}$ = the heat given to the system during an infinitestimal irreversible change.

The reviewer feels that only the first part of this equation is valid, i.e.

$$dS_{surr} = \frac{dQ_{surr}}{To}$$

and on condition that the symbol $-dQ_{surr}$ stands for the heat that should have been given to the system reversibly in order to produce the same change of state as that produced by the irreversible process. An excellent discussion of this point is given in Ch. VIII of Ref. 2 cited by the author. Thus

$$dQ_{surr} \neq -dQ$$

because dQ has been applied to the system irreversibly. If Equation 9 is not valid, so will be Equations 13, 15, and 16. The final result, however, which is presented in Equation 17, is correct, because it could be derived without the use of Equation 9 as follows:

The author has shown that

$$dW_{lost} = dQ + dQ_{rev}$$

Where dQ = heat given to the system to make an infinitestimal irreversible change from State I to State II.

dQ_{rev} = heat given to the system reversibly at a temperature To to restore its original State I.

Thus $-dQ_{rev}$ is the amount of heat which if added reversibly to the system at a temperature To would produce a change from State I to State II. Therefore,

$$-dQ_{rev} = To\,dS$$

and the lost work will be given by the equation:

$$dW_{lost} = dQ - To\,dS$$

which is the same relation obtained by the author.

Hassan H. Aboul-Secoud
College of Engineering
Cairo University, Cairo, Egypt

Comment by Author

The point raised by Mr. Aboul-Secoud is a fundamental one involving the choice of a system. If the system is chosen in accordance with the definition given in the paper, Equations 9, 13, 15, and 16 are correct as they stand with the exception of a typographical error in Equation 15. This equation should, of course, read:

$$dW + dW_{rev} = -T_o dS_{total}$$

The question involved here is whether $dQ_{surr} = -dQ$. If the system is defined so that it includes the process, i.e., so that no irreversibilities occur in the surroundings or at the boundary between the system and the surroundings, then it is axiomatic that any heat approaching the boundary must also leave it, unchanged in amount. It must be understood that everything not included in the system is in the surroundings. Thus the boundary between the system and surroundings is merely an imaginary envelope, without substance or thickness, and there can be no material or engine interposed between the system and surroundings. If the system is selected in this way, there can be no question of the validity of Equations 9, 13, 15, and 16.

It might seem that this limitation on the selection of the system would restrict the applicability of the method. However, this is not the case, for the system may always be selected in this way, and as a matter of fact, this is the best system to select in any practical problem. Of course, this does not preclude the definition of other systems for other purposes such as those considered by Keenan in Chapter VIII of Reference 2.

H. C. Van Ness
Purdue University,
Lafayette, Ind.

Help from Reader

Herbert J. Brennen, 6712 South Portshead Road, Malibu, Calif., discovered some typographical errors and an incorrect plot in the article by L. N. Canjar, (February, 1956—Page 113) "There's a Limit to Use of Equations of State." The corrections should be as follows: (1) On Page 115 directly under Equation (8) the sentence should read—"If the quantity $a^{1/3}$ which is proportional to $T_c^{1.35}/P_c^{0.5}$ is roughly a linear function of T_c/P_c." (2) Figure 2 is plotted incorrectly. The ordinate should be $T_c^{1.35}/P_c^{0.5}$ and not $T_c^{1.25}/P_c$.

Corrects Error

To the Editor:

It has been brought to our attention, by Mr. Frank L. Rubin of the Downingtown Iron Works, that an error in arithmetic appears in our paper "Determining Heat Transfer Coefficients" (May, 1956 PETROLEUM REFINER, page 227).

The constant in Equations (3) and (6) should be 34 instead of 31.2. This results in the coefficients being about 9 percent low when taken from figure one. This is on the safe side and can be considered a factor of safety. The coefficient obtained can be changed to agree with Equation (2) by multiplying the figure obtained from the curve by 1.09.

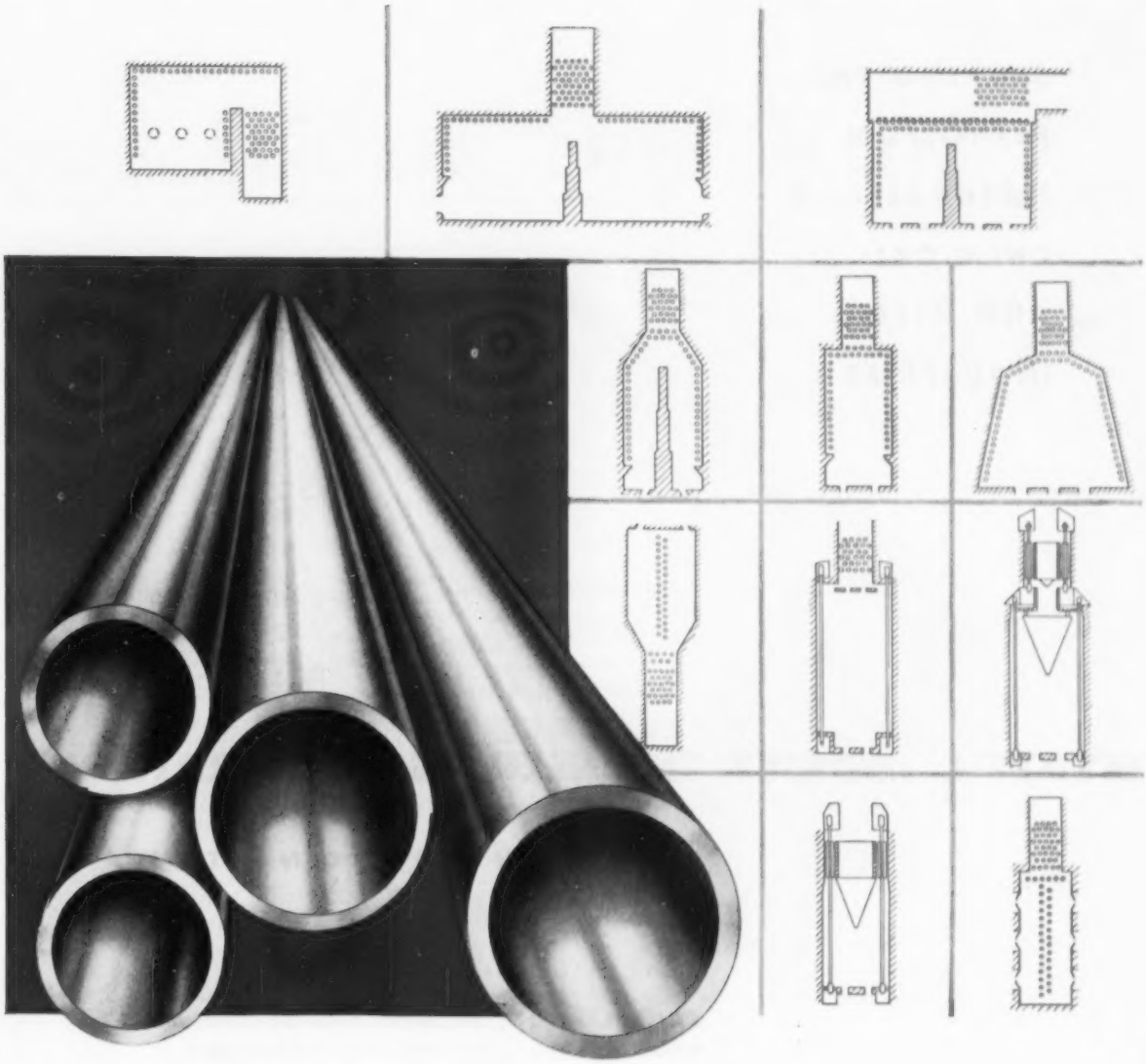
R. E. Winston,
Day & Zimmermann, Inc.
Philadelphia

Very Helpful

To the Editor:

Thank you kindly for furnishing us with a preprint of your recent article entitled "Employing the College Graduate." We have found it very helpful and would appreciate it if you would furnish us with 12 additional copies.

E. A. Lewis
Employe Relations Department
Gulf Oil Corporation
Houston, Texas



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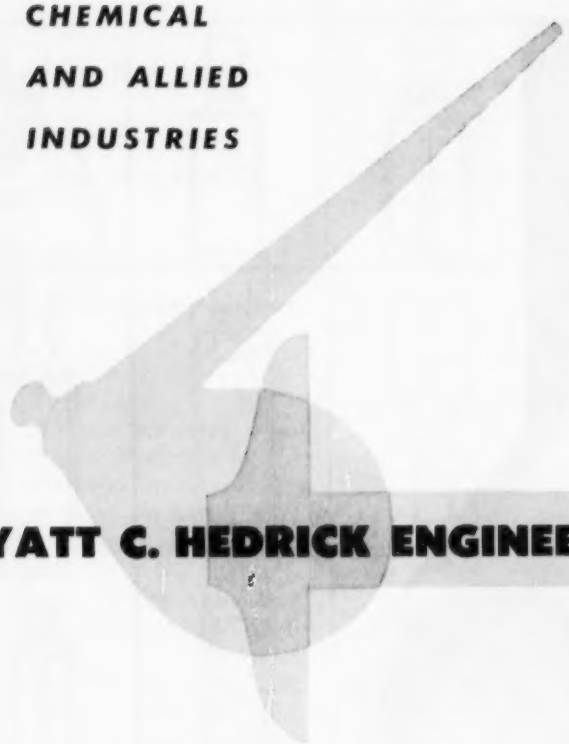

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CONSULTATION, PROCESS AND DEVELOPMENT ENGINEERING, SURVEYS AND ECONOMIC STUDIES ARE A PART OF OUR BROAD ENGINEERING SCOPE.

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A Quick Look at the Industry THIS MONTH

All Industry Outlook . . .

Threat of inflation and runaway boom has subsided. Now there is talk of business decline in third quarter. Reasons: GM's Curtice says auto sales will be 27 percent under '55—steel output is declining—steel scrap and rubber prices have dropped rapidly—durable goods inventories are at highest point in 14 months—about 10 percent of steel production is going into inventory and other metals are following suit.

Even so, U. S. Chamber says '56 will equal or exceed '55 business record. Huge capital expenditures for expansion are big reason.

—•—

Refining Trends . . .

Mid-June refinery runs totaled nearly 8 million barrels a day—5.8 percent over '55. Gasoline stocks, though cut 3 million barrels to 181.5 million by June 15, were still 9.8 percent over a year ago. Predictions are that unless inventories are lowered considerably, surplus supplies may cause trouble during summer months.

Future heating oil demand looks promising—700,000 new users of oil heating units will be added in '56.

Jet fuel use keeps climbing—totaled 5.6 million barrels in March, 9.4 percent over same period in '55. Jet fuel stocks reached 4.3 million barrels on April 1—21.6 percent over '55.

—•—

Postings On Octane Race . . .

Gulf, Shell, Texaco, Conoco and DX-Sunray say they are ready with 100 octane whenever competition forces the move—**Octane race pioneer** Sunoco expects to have 100 octane in 350 of its Florida stations by end of July—**In '56,** less than 1 million cars will have 9to 1 compressor ratios that require high octane numbers—**Nevertheless,** refiners will spend nearly $2 billion in research and production before octane race is over. **Midst the hue and cry** comes a heavy mumble that most cars don't need super-high octane. Esso mentioned this point in introducing "Golden Esso Extra." Chances are small companies will start campaign of their own to assure markets for the ordinary run of cars.

—•—

Imports and Prices . . .

"Big" and "little" continue to differ on crude price hike. Independents say majors are flooding market with "cheap" imported oil to keep crude prices down. Result: Over-supply plus resulting low prices plus rising costs will force more and more small operators out of business. Solution: Curb imports then hike prices, say the indys.

Standard of Calif. Prexy Peterson joins Jersey and other majors in saying higher crude prices are not justified at this time. Reason: Over-abundant supply of crude.

—•—

What Price Comfort . . .

If predicted sales for auto air conditioners materialize, volatility in motor fuel will be an increasing headache. Sales are expected to jump from 176,000 in '55 to 1 million in '59. Latest studies indicate that RVP limits on gasoline are reduced 0.7 on the average by installation of air conditioning in a car.

A Quick Look at the Industry (continued)

Nitrogen Moves Ahead of Demand . . .

For the first time, nitrogen supplies are ahead of consumption. Several companies have sliced 3 to 5 dollars off the $85 posted price for ammonia—and like cuts are being made in liquid and solid products.

Present synthetic ammonia capacity: 4.1 million tons a year with demand falling considerably short of that figure. Nitrogen excess could be a boon when you consider our growing population and resulting scarcity of tillable acreage.

—•—

New Developments . . .

One manufacturer claims to have fuel injector that would cut truck fuel costs 10 percent. A leading trucking firm is considering a trial run.

Expected rush to build isomerization units has not materialized as yet. Reason: Lack of process development to resolve this new principle into commercial units. However, most refineries concede that isomerized products are excellent blending materials for motor fuels—that an upswing in isomerization unit construction is on the way.

Alkylation is now being used to make 96.8 F-1 octanes unleaded by combining excess isobutanes with butylenes. This helps refiners' volatility picture, plus providing additional source of octanes. Now that reforming capacity can supply about 25 percent of gasoline demand, more emphasis will be given to alkylation.

Trend to hydrogenation continues. Catalytic hydrogenation of crude residues shows great promise in production of lubricating distillates—this may be answer to growing demand for very light lubricating oils in automotive equipment. Also: Mild hydrogenation is said to be almost only practical way to achieve thermal stability and water tolerance characteristics required by jet fuels.

—•—

Road Bill Hikes Taxes . . .

How much will the petroleum industry benefit from the federal road-building program? Directly you can figure that asphalt consumption for roads will jump 44% for the next few years; and oil products for the same purpose will be up 49%. For the motorist, reduced driving costs because of better road conditions should more than offset new taxes on gasoline and tires that he will have to pay.

—•—

Gasoline is Big Business . . .

American auto owners spend $12 billion a year on gasoline. Six out of every 10 families own cars—and they spend $325 a year to operate them. Sixty percent of that $325 goes for service station items. Lion's share of each dollar—42.2 cents—goes for gasoline. Motor oil represents 4.2 cents; new tires, 5.3 cents; and batteries, 2.1 cents.

—•—

New Oil Fields Show Promise . . .

A near-record 106 new oil fields were added to the nation's list during May. Most of them were of minor importance, but several stood out from the rest. They were: Signal O&G and Standard of Texas' Lea County, New Mexico, 45-gravity oil discovery testing for 1900 barrels a day; Gulf's 1500-barrel find in McClain County, Oklahoma, flowing 42-gravity; a 310-barrel, 47-gravity well in Gaines County, W. Texas by Stanolind; another in Lea County, N. Mex., good for 305 barrels of 44-gravity by Humble; and J. D. Hancock Oil's wildcat in Ector County, W. Texas, completed for 270 barrels of 32-gravity oil per day.

MATCHLESS STEAM HOSE

"U. S. Matchless #5 does 5 different jobs,"

says refinery division superintendent

"It always passes our strictest lab tests."

A mechanical division superintendent of a leading Midwestern refinery says:

"U.S. Matchless Steam Hose always passes our central maintenance department tests, and we've always had good experience with it. The neoprene cover is oil-resistant. The hose is highly flexible and light in weight. Asbestos ply, under the cover, conserves heat. Wire braid preserves static ground."

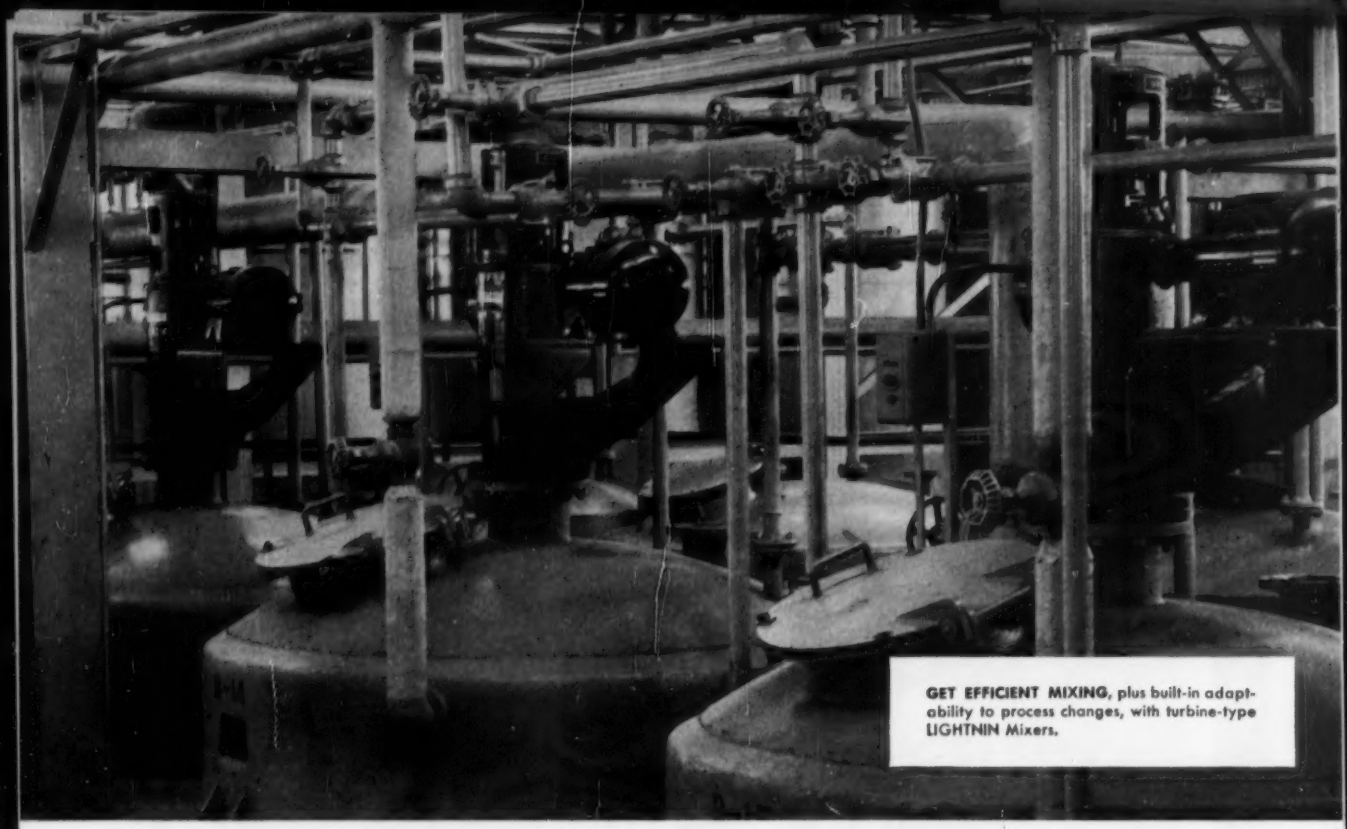
This great "U.S." hose is serving many industries in many ways. It is obtainable at selected "U.S." distributors, at any of the 28 "U.S." District Sales Offices, or write us at Rockefeller Center, New York 20, N. Y.

Uses in refinery for U.S. Matchless® #5 Hose:

- As a firefighting hose, for safety-checking atop the 235-ft. cracking unit (see picture above).
- In propane tank, to thaw bottom of gauge glass in cold weather (see inset picture above).
- In pump room of cracking unit, as a steaming line to get gas traces out of the unit.
- On propane transfer line, to prevent orifice from freezing in cold weather.
- Enables construction crews to run temporary steam lines more cheaply and quickly than using pipe.

Mechanical Goods Division

United States Rubber



GET EFFICIENT MIXING, plus built-in adaptability to process changes, with turbine-type LIGHTNIN Mixers.

Use this **proved method** *to get good fluid mixing*

You can't afford to *guess* about fluid mixing. And you don't need to.

On any mixing operation you can get factual answers to questions like these, to guide you in your mixer selection:

1. What precise balance of *fluid flow* and *fluid shear* will do my mixing job best?
2. If this balance can be attained in different ways, what is the *most efficient* and economical way?
3. In scaling-up, does power required per unit volume remain constant? If not, by what factor does it increase or decrease?
4. Will the mixer transmit the required power to the mix, and do it efficiently?
5. Can the mixer be installed without special construction? Can I get standard replacement parts quickly if I ever need them?
6. Am I protected against mixer obsolescence in case of a process change?

You *know* the answers to these vital questions, when you mix with LIGHTNIN Mixers.

Predicting results

Even on the simplest mixer application, your LIGHTNIN sales engineer's recommendation is based on thousands of pilot runs, plus years of in-the-field experience.

On complex mixing jobs, pilot runs at MIXCO quickly find the impeller-to-tank diameter ratio and input power that will produce the optimum fluid regime most economically. Scale-up is *guaranteed accurate.*

Mechanical economy

Your mixer investment goes into equipment that is mechanically up-to-the-minute. Hundreds of *standard* LIGHTNIN power-speed combinations (interchangeable in many models); widest possible choice of in-stock materials and interchangeable components, give you assurance of correct application, smooth running, and flexibility when you need it.

For fluid mixing that does what you want it to do, call in your LIGHTNIN Mixer representative. (He's listed in Refinery Catalog.) Or write us direct.

GET LOWEST-COST MIXING, gasoline blending, suspension of BS&W in crude, with LIGHTNIN Side Entering Mixers. New rotary mechanical shaft seal ends stuffing-box repacking forever; stops leakage; runs for years without adjustment. Yet you can replace it in minutes if ever necessary.

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FOR LATEST MIXING INFORMATION and full description of LIGHTNIN Mixers, send for these helpful bulletins:

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- ☐ B-112 Laboratory and small-batch production types
- ☐ B-110 Condensed catalog showing all types
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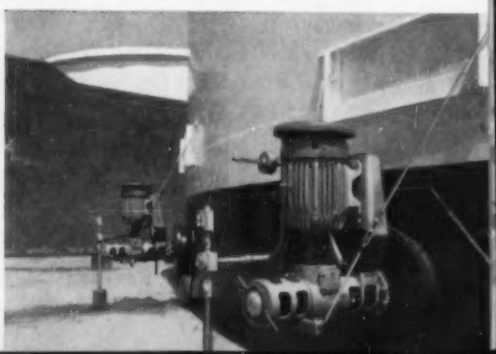

The Plight of Basic Research—

By KENNETH A. KOBE, University of Texas

IN THE MIDST of our race to lead the world in industry and defense, two glaring questions have arisen —questions which may have a vital long range influence on our country's progress:

(1) Is industry's growing demand for applied research detracting from basic research?

(2) Is basic research to be government controlled—or industry sponsored?

When asked about the training of men it hires as scientists and engineers, industry management replies that it wants men not only *trained* in fundamentals, but also able to *apply* the fundamentals to the problems confronting them. This desire for "double-barreled" qualities in graduates creates serious problems for education.

At the graduate level faculty and students are presented with a choice of research problems that must be solved for the Master's or Doctor's degree. Excluding large government-sponsored defense projects, university research for a thesis represents an individual piece of work. Each student produces his "quanta" of new knowledge and then moves on to industry or, too infrequently, to academic work.

The research produced by the student depends on his interests, background of training and capabilities—and to a large degree, the professor who suggests the problem and sponsors the work.

Although many schools have outstanding equipment for certain fields of research, this is not true of all schools—and the extent of many research projects depends on the equipment that is available.

Keeping these important background facts in mind: Should graduate research work be basic or applied? Should it represent new data (basic)? or new processes (applied)? Should it be theoretical (basic) or industrial (applied)? Let's look at some facts of this philosopher's stone.

That industry expects *applied* research from universities can be easily illustrated. Unit operations and unit processes have—at least until the advent of chemical engineering science—constituted chemical engineering. The unit operations have represented techniques used to conduct processes. Research on the processes has comprised process variable studies, equilibrium and kinetics of the reaction.

A logical step is to apply the knowledge of unit processes to some natural resource, some waste material, some raw material that can be utilized more effectively, or some product that can be made more cheaply.

On the other hand, this same industry expects such *basic* research work as:

- **New design methods** for heat and mass transfer equipment, for reactors, for fluid flow.
- **New techniques,** as fluidization and gas chromotography, super-pressure equipment.
- **New generalizations,** as new applications of the law of corresponding states.
- **New mathematical approaches,** as difference methods, Laplace transforms.
- **New theories,** as drying, fluidization, fluid boundary layer.

Although industry keeps increasing its demands for graduates with *applied* research background, it has long been established that *basic* research is the primary concern of universities. The freedom to pursue lines of research without regard to the dollar sign, the accumulation of knowledge of chemical and physical processes for its own sake, and the unhurried search of all aspects of a theory or phenomenon attract to universities individuals who desire to extend the frontiers of knowledge.

The graduate student working on basic research makes himself an expert in some small but fundamental field. He has been through a rigorous mental discipline that enables him to bring the same intensive, analytical perception to bear on some new problems in a different field.

Is basic research, the foundation of all progress, being sacrificed to meet industry's demand for applied research?

Basic research *should* be a primary concern of industrial research management. The well of fundamental knowledge can be pumped dry unless industry concerns itself with maintaining and replenishing the supply. Both single industries and trade associations have recognized the need for basic research and have subsidized it with grants of money, equipment and men.

Apparently such support has been insufficient, for the Federal government has come to the support of basic research through the National Science Foundation, Office of Naval Research, Office of Ordnance Research, Air Research and Development Command, and others. Such research grants have enabled more long term basic research projects to operate.

So that universities will not turn entirely to government support, industry should—and must—sponsor more basic research projects, i.e., API's research programs. The cost is small in terms of over-all industry

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Du Pont Lube Oil Additives	$1,830	12.0%	$1,860	12.0%	$2,000	12.5%

Shown above are nine typical situations—three locations, three additives. They illustrate how substantial sums can be saved when you order Du Pont additives in 4,000-gallon tank-car lots. The saving is over the costs of the same quantities in less than carload lots, in drums. The total savings shown reflect lower product cost and lower freight rates.

Four-figure savings are yours each time you order a Du Pont additive by the tank car

If you have been buying your additives in drums—either in carload or less than carload quantities—it will pay you to investigate the savings in delivered cost that are possible by ordering in tank-car lots.

For example . . .

The above chart shows how refiners in three areas can save from $1,680 to $2,400 simply by ordering a Du Pont additive by the 4,000-gallon tank car instead of equal quantities in partial car shipments in drums. These figures are, of course, based on the freight rates for only three locations; savings will vary somewhat for other receiving points. However, the saving will be decidedly worthwhile anywhere . . . for any one or more of the products listed.

How much can you save?

To answer that question for you, one of our nearby representatives will be glad to call at your refinery, study your freight rates and inventory patterns. He will then determine the most convenient handling method for you and figure the exact saving you can make. Phone, write, or wire us . . . today.

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and the results are large in terms of industry benefits and prestige.

Industry opens up many new fields of research in their fast-moving scouting and development programs. Many of these end too soon because the economics are not favorable at the time. Others leave only partly explored but interesting by-paths which would produce additional data to complete the picture and enable an adequate theory to be devised.

Industry should bring more of these incompleted research pictures to the attention of the schools so they may consider the feasibility of research projects in these fields. Remember—these projects have two vital functions—the new knowledge obtained and the training of an individual in research.

Unfortunately, few graduate students in science and engineering now come to a university without some financial inducement—the athletes are no longer a special class. This fast-growing trend to finance intellect as well as brawn points up still another university need that industry should do something about—maintaining a store of fellowships at schools from which a particular industry draws its personnel. In this way only will a steady flow of master's and doctor's degrees be assured.

It is far better for a graduate student to be a holder of the XYZ Oil Company Fellowship than to be a government-sponsored Fellow.

Whether basic research will continue to suffer because of industry's demand for applied research—whether basic research is to be government controlled or industry sponsored—are questions that industry management alone can answer.

Business Is The Bulwark

OUR ONCE-STRONG constitution appears ailing.

Its binding limitations upon government are weakening every day. For the most part, we cut and destroy these limitations ourselves. Tyranny is so widespread in the world that many people seem to think we should have tyranny—government absolutism—here, too, in order to fight the advance of tyranny in other parts of the world.

Further from Clarence E. Manion, Dean Emeritus of Notre Dame's School of Law: "We cannot defeat despotism in Moscow by setting up a rival despotism in Washington. Communism is completely centralized government in the hands of godless gangsters. Once government power is centralized, you may depend upon the godless gangsters of Communism to take over. It was thus in Hungary, Czechoslovakia, Poland and every one of the 16 countries captured by the Kremlin since the end of World War II."

It could possibly happen in America. The bulwark against its happening is the American businessman.

Neither the educators nor the labor leaders nor the politicians are the natural and effective leaders of the American people. The American people are led by American businessmen—and oil men comprise one of the most influential business groups.

Businessmen lead the crowds from one product to another; from one area of the country to another; from one practice and habit to another. Through their advertising, businessmen publish and write all the American newspapers, and conduct all the radio and television programs—so states Dean Manion.

Directly or indirectly, businessmen pay the lion's share of all American tax money. Precisely because American business leadership has ignored the source and sustenance of all American business—the Constitution of the United States—the American people are now permitting the Constitution to be weakened by socialistic demagogues in and out of public office.

American businessmen can help restore the freedom-giving power of our Constitution. They can do it by shaking off their apathetic attitude toward encroaching government control. They can do it by making sure every piece of advertising contains such cautionary warnings as: "Liberty is limited government." Or, "Constitutional states rights are our best defense against Communism."

This is the type of business leadership that Dean Manion says can turn the socialistic tide which now threatens to weaken the Constitution and every vestige of American freedom.

Gasoline Stocks Should Be Lower

DESPITE RECORD consumption of gasoline, stocks of this product have not been reduced as rapidly as they should for this season of the year. Only 16½ million barrels have been taken from motor fuel inventories since the beginning of the heavy gasoline consumption season at the end of March. During the same period of 1955, drafts totaling 18⅔ million barrels had been made from gasoline storage.

Consequently, gasoline supplies at mid-June were 16⅕ million barrels greater than they had been at the same time last year. At the start of the gasoline season, inventories were but 14 million barrels larger than were on hand a year earlier. Therefore, gasoline in tanks is at a high level, totaling 181½ million barrels on June 15.

As a result, localized gasoline price wars have occurred in a number of areas, and are likely to continue for a while. As long as this supply condition exists, higher crude oil prices are unlikely. Higher prices for U. S. crude oil seemed quite possible until recent months, but present conditions point to these prices remaining at present levels, generally.

This situation has occurred in the face of all-time high consumption rates, and has been the result of record volumes of gasoline manufactured.

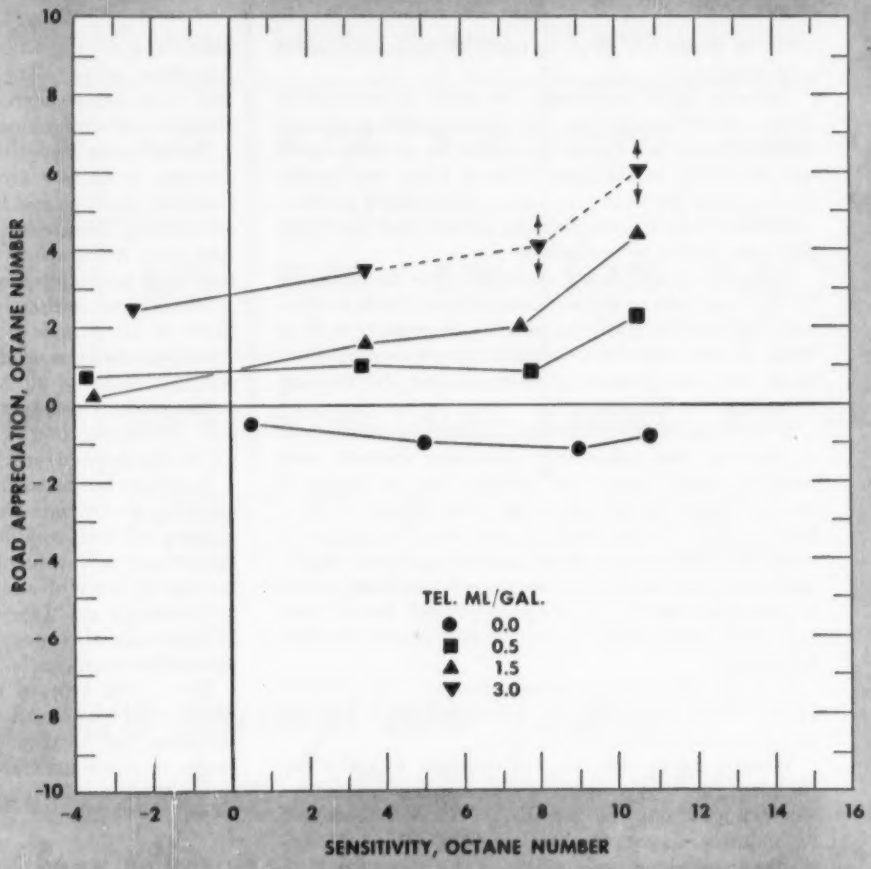

Fig. 1. Sensitivity versus appreciation. Note that the appreciation at any given sensitivity level increases with lead concentration.

Blending Hydrocarbons for Maximum Octane Potentials

By F. D. BUERSTETTA
Ethyl Corporation, Detroit, Mich.

The manufacture of high-octane gasolines to meet today's and tomorrow's automotive demands is putting increasing pressure on the refiner. To meet these requirements, the available hydrocarbon components in the refinery must be blended to best advantage to give maximum performance on the road.

Each octane number at the 100-octane level may cost as much as 15 to 20 cents per barrel. Thus there is a marked incentive for insuring that every laboratory octane number, obtained at this great expense, provides corresponding antiknock performance in cars on the road.

Hydrocarbon blends studied

As part of a continuing Ethyl Research program to establish the fundamentals of laboratory versus road antiknock quality, a study was recently conducted in which the behavior of blends of pure C_7 and C_8 hydrocarbons was examined.

Within this C_7-C_8 range, the four basic hydrocarbon types — olefins, paraffins, naphthenes and aromatics — were blended in varying proportions. Actually, a mixture of isooctane and *n*-heptane was used as the paraffin constituent to permit maintenance of a constant Research octane number while investigating the effects of tetraethyllead concentration and variations in hydrocarbon-type composition. Toluene, diisobutylene and methylcyclohexane were selected to represent the aromatics, olefins and naphthenes, respectively. Each of these hydrocar-

(Advertisement)

Send for your free copy of a technical paper entitled "Octane Possibilities with C_7-C_8 Hydrocarbons" by F. D. Buerstetta and T. W. Warren. Address your request to Box 24, Ethyl Corporation, 100 Park Avenue, New York, N.Y.

bons was blended in concentrations of 20, 40 and 60 per cent by volume with the proper paraffin mixture, giving nominal Research octane levels of 92, 96 and 100 at each of four tetraethyllead concentrations—0.0, 0.5, 1.5 and 3.0 ml. per gallon.

Each blend was evaluated in single-cylinder laboratory test engines and was then rated in the 9 to 1 compression-ratio engine of a 1955 passenger car equipped with an automatic transmission. Road ratings were made by both the Modified Uniontown and Modified Borderline techniques.

Road appreciation defined

Some of the test results are summarized in Table 1 in terms of road appreciation, which is the road antiknock rating of a fuel minus its Research octane number—or the bonus obtained in actual engine performance over the indicated laboratory knock rating.

The general analysis of data shown in Table 1 may permit a refiner to achieve better road performance than could be secured by using only Research octane number as a guide. It will be seen that aromatics should be maximized and olefins minimized as much as possible when making top-octane fuels. Since most of today's catalytic reforming processes eliminate naphthenes through dehydrogenation to aromatics, consideration of them is somewhat academic, but nonetheless interesting.

Further evaluation of the large quantity of test data obtained from this project indicates a most interesting correlation between appreciation and the concentration of tetraethyllead. Figure 1 shows a plot of sensitivity versus appreciation with points representing the same tetraethyllead concentrations connected. It can be seen from Figure 1 that the appreciation at any given sensitivity level increases with lead concentration.

Conclusions

The general conclusions which can be obtained from the study are as follows:

1. Best over-all antiknock performance can be obtained by blending a high proportion of aromatics with paraffins and adding the maximum amount of tetraethyllead.

2. Where low-speed knock resistance is critical, high aromatic content is necessary.

3. Where high-speed antiknock performance is critical, high aromatic content is less important, but maximum tetraethyllead concentration is still essential.

Table 1. Average change in road antiknock appreciation with addition of aromatics, olefins or naphthenes to paraffins in the C_7-C_8 range.

Research Octane No.	Added Component	Modified Uniontown	Modified Borderline	
			Low Speed	High Speed
92	Aromatics	+0.6	+1.1	+0.6
	Olefins	+0.3	+1.1	−2.0
	Naphthenes	+0.6	+2.0	+3.8
96	Aromatics	+0.9	+1.7	+0.6
	Olefins	+1.6	+1.1	−3.3
	Naphthenes	+2.4	+4.2	+2.7
100	Aromatics	+0.8	+1.5	−0.7
	Olefins	+0.5	+0.0	−5.7
	Naphthenes	+3.4	+3.7	+1.7

HOW Ethyl Research can help you

At today's high octane levels, the science of blending hydrocarbons has taken on more and more importance. As a service to the oil industry, Ethyl Research has launched a hydrocarbon blending program of its own to complement the intensive effort which the industry is devoting to this problem.

We are now testing many new blends in our laboratories and in high-compression engines on the road. Much of the data from these tests is being interpreted in terms of "road appreciation" to give refiners a better idea of the effectiveness of each blend. Write for a copy of "Octane Possibilities with C_7-C_8 Hydrocarbons"—another in the continuing series of reports from the Ethyl Corporation on fuel blending and other studies of vital interest to refiners today.

For further information, just call your Ethyl Representative. He'll be happy to arrange an appointment for you with one of our Technical Representatives.

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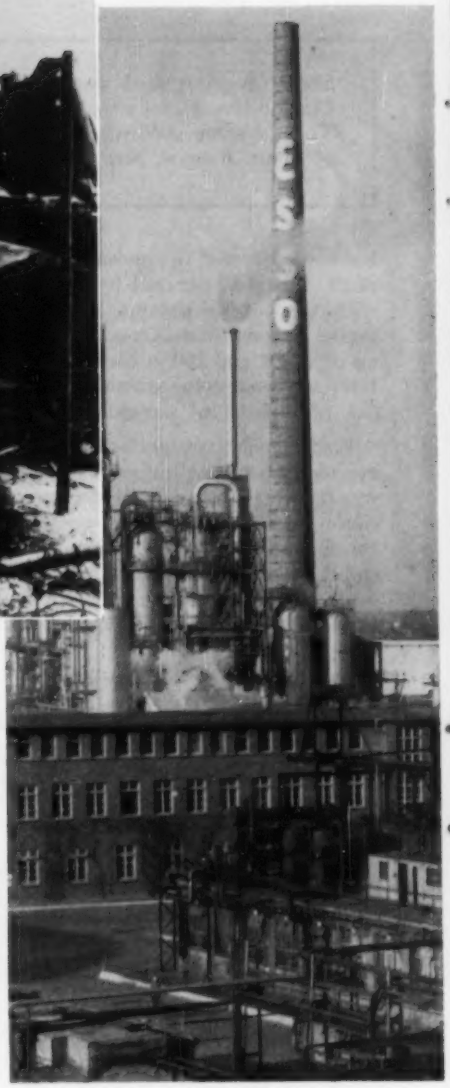
IN 1945 The Esso refinery at Hamburg, Germany, as it looked at end of World War II.



TODAY

Two Jersey Affiliates Build To Meet Postwar Demands

• In the Rocky mountains, Carter has adopted the latest refining techniques to the new requirements of its market area.

• And at Hamburg, Esso has rebuilt its war-ravaged refinery to supply German needs for petroleum.

IN THE RACE to meet postwar demands for petroleum products, Standard Oil Company (New Jersey) has held its place among the world's leading refiners by maintaining a rigorous building program within its affiliated companies.

Two of these companies point out divergent trends in postwar refinery construction.

Overseas, where construction has been to renovate war-damaged refineries and expand operations *to meet the requirements of new markets,* Esso, A. G., has rebuilt its refinery in Germany and is planning a second.

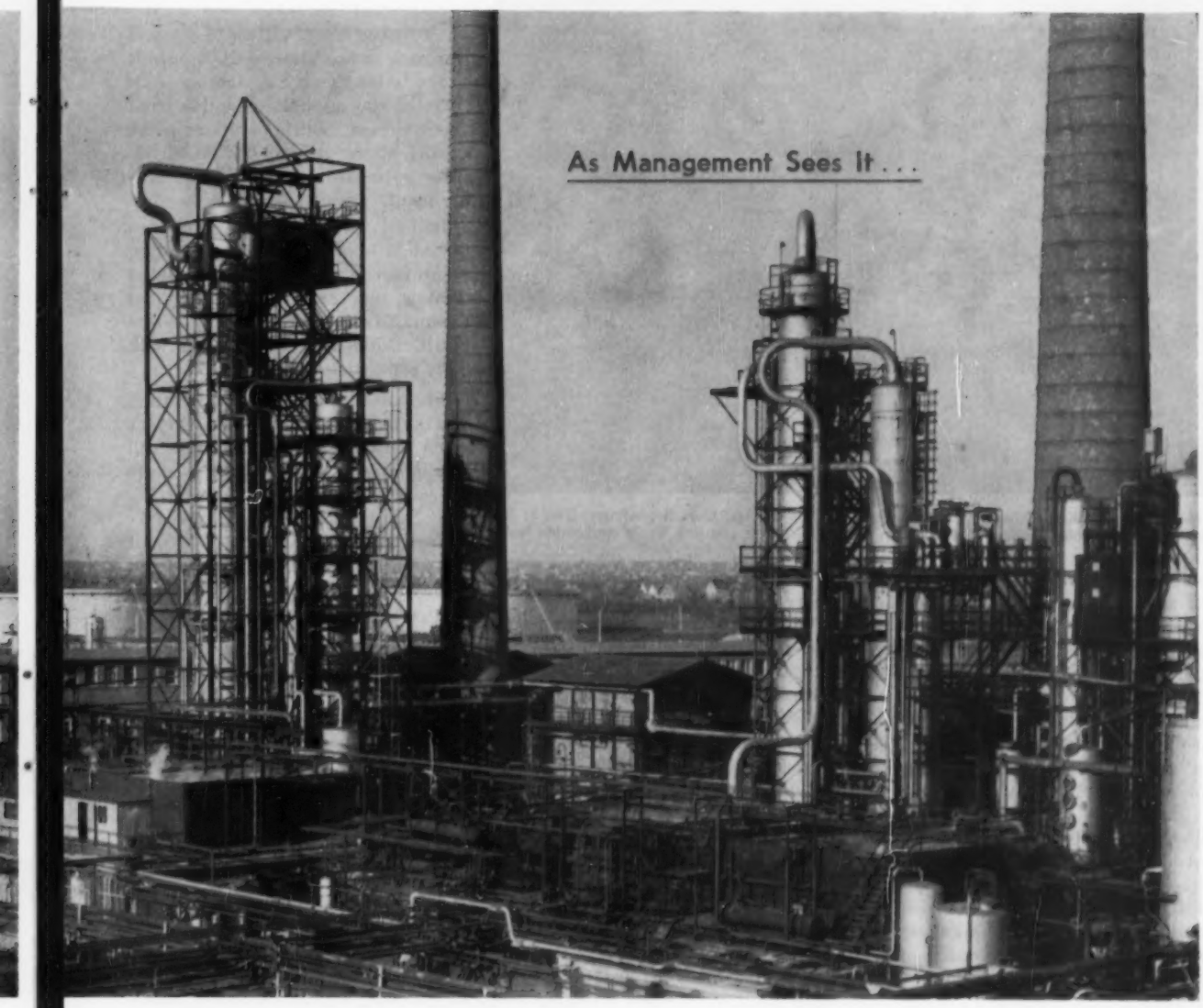
Last month, PETROLEUM REFINER covered the past decade of construction at Humble Oil & Refining Company's Baytown, Texas, refinery. This month, it takes up two other affiliates with postwar construction programs which have helped keep Standard Oil Company (New Jersey) among the world leaders in petroleum refining.

In the U. S., where construction has been aimed at adopting new techniques for increasing product yields and supplying products *to meet new requirements of old markets,* The Carter Oil Company has consolidated four refineries into one operation at Billings, Mont.

Here is a report on ten years of construction in these two companies:

CARTER AT BILLINGS

The old story of reducing the number of refineries while increasing total capacity is brought out in an exam-



The Hamburg refinery as it looks today. Eighty-percent destroyed during World War II, the refinery has been increased from a prewar capacity of 14,000 barrels a day to its present 42,800 bpd.

ination of ten years of growth in The Carter Oil Company. But a new story is told in how this Standard Oil Company (New Jersey) affiliate shifted its output to meet the requirements of new market conditions in the Rocky Mountain area.

Remote from residual-fuel-oil markets and faced with a declining need for residual fuel to fire steam locomotives, Carter installed the first commercial fluid coking unit to free itself from the necessity of producing residual fuel. The result was an almost 16 percent increase in amount of gasoline produced from crude.

Ten years ago, Carter had only recently taken up refining operations with the acquisition of four small refineries in Montana and Wyoming. At Billings and Cut Bank, Mont., and Lovell and Newcastle, Wyo., these plants had a combined daily crude capacity of 16,500 barrels.

Today, the company operates only one refinery, a 23,500-barrel-a-day plant at Billings, geared to meet the demands of its particular market.

In 1949, a completely new refinery went on stream at Billings, and four original refineries, including the old Billings plant, either were sold or dismantled.

The refinery started with a 20,000-barrel-a-day atmospheric and vacuum distillation unit, a 9200-barrel-a-day bauxite desulfurization plant and fluid catalytic-cracking capacity for 11,000 barrels a day total feed. In the next five years, Carter increased its catalytic-cracking capacity to 25,000 bpd total feed; installed a non-selective polymerization unit and took up fluid coking.

Fluid Coking—The fluid coking unit, which went on stream in 1955, increased the refinery's gasoline out-

This is the new fluid coking unit at Carter's 23,000-bpd Billings, Montana, refinery. Unit at far right takes low-value residual oil and breaks it down for conversion into highly marketable fuels.

put by about 1500 barrels a day. And in addition to refining gasolines and heating oils from residuals and heavy crudes, gave the refinery an output of petroleum coke.

The unit produces its own fuel, consuming 40 tons of the new oil coke a day. The additional 160 tons a day is used in the metallurgical industries of the Rocky Mountains.

Essentially, the process is an economical way of converting low-value heavy fuel oil, or heavy crude oil, into light oil products, with only a little coke left over as a byproduct and no heavy oil. When used as feed stock in the coker, the value of residuals is upgraded to about that of crude.

At Billings, the unit is fed a low-penetration pitch direct from the vacuum unit and produces gasoline, gas oil for catalytic cracking, and fluid coke. Distillate stocks previously required to cut the viscosity of the pitch to residual-fuel requirements are freed for other uses, one of which is additional feed for the catalytic cracking unit.

The most recent new facilities to go into operation at Billings have been a 2500-barrel-a-day Hydroforming unit and a 6900-barrel-a-day Hydrofining plant. Both these units went into operation in January, 1956.

ESSO AT HAMBURG

In Germany, where it is getting ready to build a refinery at Cologne, Standard Oil Company (New Jersey) is represented by Esso, A. G., a wholly-owned subsidiary with a refinery at Hamburg.

The Hamburg refinery, with a prewar capacity of only 14,000 barrels a day, was 80 percent destroyed when rehabilitation work was started there in 1945.

Since then capacity has been increased to 42,800 barrels a day. And when the new 60,000-barrel-a-day Cologne refinery is completed in 1959, Jersey Standard will have more than 100,000 barrels a day of German refining capacity.

The Hamburg refinery was built in 1928 by Ebano Asphalt Werke, A. G., principally for the production of asphalt. It was operated under this name until 1953, when a merger was completed with Esso.

The first half of the ten years of construction since World War II was spent in restoring the Hamburg refinery to the condition it was in when the war started in 1939. After that attention was turned to diversification and adding new equipment to keep up with the growing European demand for petroleum products.

Rehabilitation—The first work started in restoring the war-damaged refinery was to put part of its crude-distillation facilities back in operation. By September, 1947, the refinery was on stream again with one of its three pipe stills operating at 3600 barrels a day and an asphalt oxidation working at a capacity of 700 barrels a day.

Within a year, a 10,000-barrel-a-day pipe still had been returned to service. And by 1949, the other still was back in operation at 2000 barrels a day. Also that year, another 700-barrel-a-day asphalt-oxidation unit was restored, and operations were started at the refinery's 5200-barrel-a-day naphtha-hydrochlorite sweetening plant.

In 1951, two processing units were placed in operation: an acid-treating plant for industrial lube oils and a treating and redistillation plant for the manufacture of SBP and White Spirit. Both went on stream with daily capacities of 1900 barrels.

The last of the major rehabilitation was completed the following year when the third asphalt-oxidation still was put into service with a daily capacity of 700 barrels.

Construction—As early as 1951, it was clear that additional land would be needed to expand the refinery to keep up with the rapid recovery of Germany itself. That year, enough land was acquired to double the plant site, increasing its area to more than 124 acres.

The refinery's first new construction was completed in 1953. During the year, two new process units were placed on stream: a 9900-barrel-a-day catalytic-cracking unit and a thermal reformer with a daily capacity of 3760 barrels.

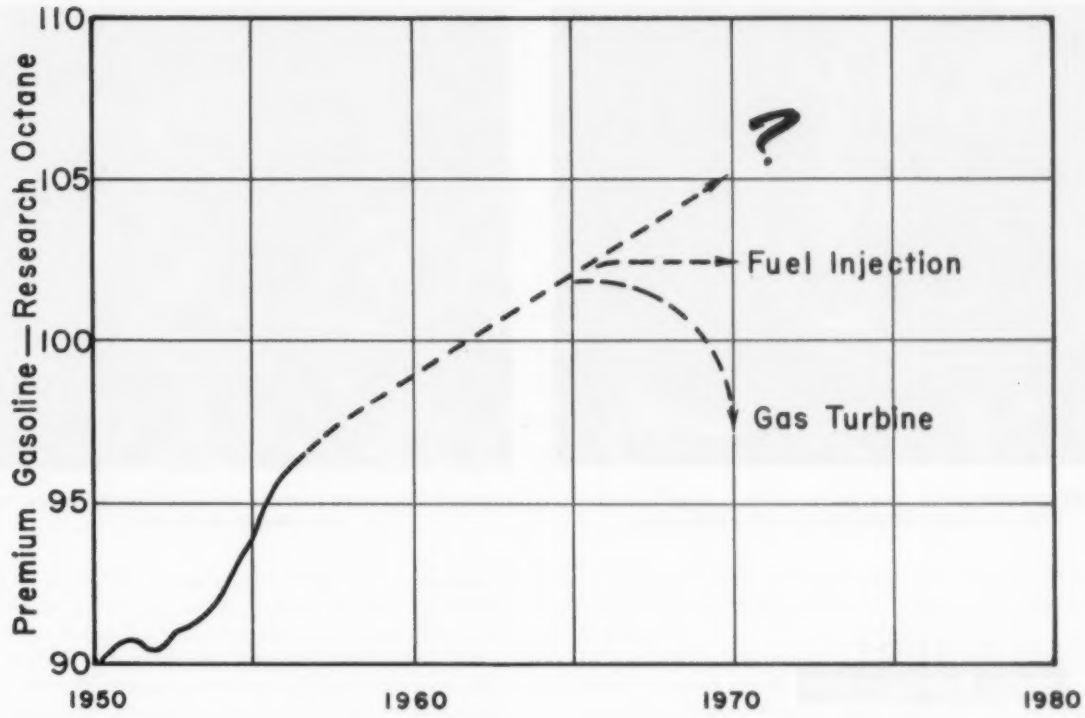
Also a new combination vacuum-atmospheric distillation unit was placed in operation with a daily capacity of 24,200 barrels. This, with the refinery's original distillation equipment, brought its total crude capacity to 37,800 barrels.

Within a year, the refinery's total crude capacity had been expanded to reach its present 42,800 barrels a day.

Three other units also were put in operation in 1954, and construction was started on a new Hydrofiner. The three new facilities were a 100,000-ton-a-year Girbotol gas-desulfurization unit, a 10,000-ton Claus sulfur-recovery unit and vacuum-flash unit with a daily capacity of 2750 barrels.

Since then, Esso has completed its Hydrofiner, built to treat 6000 barrels a day of distillate, and construction has been started on a new Hydroformer. ##

More As-Management-Sees-It Articles on Pages 254-274 this issue.



Higher Octanes or Not?

IN THE PAST TEN YEARS the growth in gasoline demand was equivalent to about 7 percent increase per year. Even so, this growth period was accompanied by a shift in emphasis from processes which increase the through-put of a refinery to processes which up-grade the finished products.

A good example of product up-grading was the introduction of the reforming processes. Five years ago they existed in such limited capacity that they could supply only about 1 percent of the total gasoline demand. Now their capacity has grown to the point where they can supply 25 percent.

A great deal of the present construction and expansion programs within the refining industry are based on an anticipated market of steadily increasing octanes. Any developments which threaten to change this trend must be given serious consideration.

In this issue we present two developments in the design of automotive engines. One is the gas turbine which threatens to make octanes obsolete. The other is fuel injection which suggests less dramatic changes in motor fuel quality but nevertheless promises to reduce the octane requirement of the engine.

After you have read the following two articles on these developments, you will see what strides are being made to get these developments into commercial use. In the meantime the automotive engine designers are sure to reach for greater horsepower by increasing the compression ratio and thus produce engines which require higher octane motor fuels in order to give smooth knock free performance.

There is little doubt that these higher octanes are going to cost money. One oil company is going to market a separate high octane grade fuel so as not to penalize the motorist whose car will be satisfied with a regular grade gasoline. It seems likely that a similar system for low octane turbine fuel will be introduced if the turbine engine is to get started into commercial use.

When will the octane race stop? There are a lot of varied answers to this question. But one thing seem certain—the octanes are going to be around for a while. At least long enough to pay out new octane improving facilities on the basis of the competitive position of the resulting motor fuel.

These developments may affect the octane race . . .

Turbo Autos for the Future . . . . p. 138

Fuel Injection Changes Emphasis p. 145

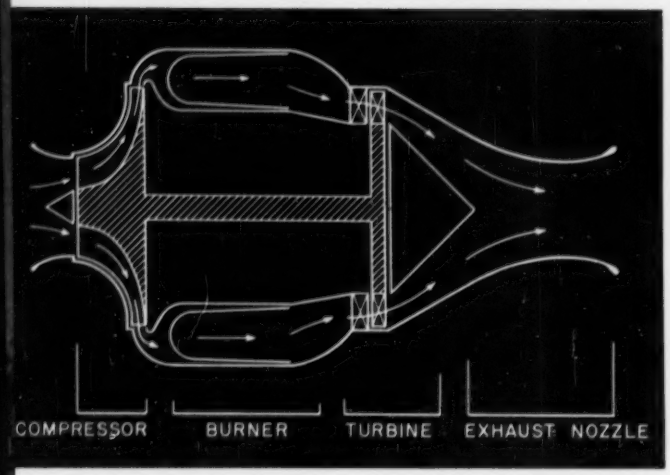


FIGURE 1—Although the jet engine is the simplest gas turbine, it is not practical or efficient for powering automobiles.

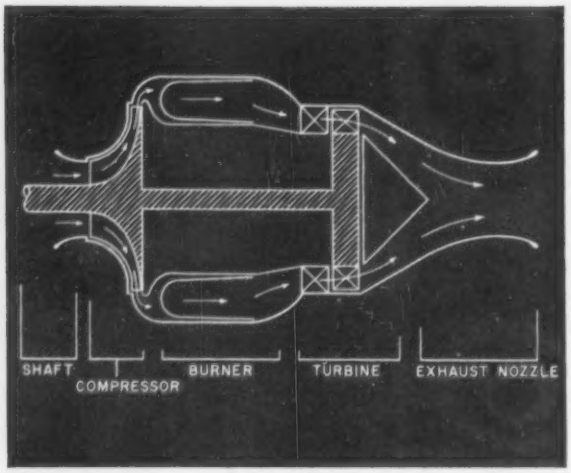


FIGURE 2—The single-shaft turbine would have to be too large to give adequate acceleration.

Turbo Autos for the Future

Some development is still needed, but the gas turbine should find commercial service in automobiles within the next decade.

Lamont Eltinge
Standard Oil Company (Indiana)
Whiting, Indiana

GAS-TURBINE ENGINES for automobiles, trucks, buses, and off-highway equipment are an interesting possibility of the next decade. Several companies are working on them. Respected engineering authorities do not agree whether or when gas turbines will enter the automotive field. Nevertheless, interest and development effort are great.

There is better agreement on some of the technical details of the gas turbine engine. One particular design of gas turbine appears most likely. The amount and type of fuel it requires will be major factors in the acceptability of the gas turbine; both are fairly predictable. The advantages this type of gas turbine will have over gasoline and diesel engines are apparent, as are the hurdles which must still be surmounted. Thorough consideration of these factors gives some indication where and when the gas turbine may fit into the automotive picture.

GAS-TURBINE DESIGNS

The term *gas turbine* covers a wide variety of cycle arrangements and equipment configurations, each of which has different characteristics. For instance, it covers a complicated 20,000 horsepower powerplant with multiple compressors and turbines, intercooling, reheat, regeneration, and possibly operation on a closed cycle. Such a gas turbine would be efficient but it would also be complicated, expensive, heavy, bulky, and consequently totally unsuited to automotive service. A simple 50-hp engine with one compressor, one turbine, and one burner is also a gas turbine. It is small, light, and cheap enough for automotive applications, but it would perform poorly and require too much fuel. Automotive gas turbines lie between the two extremes, but are relatively simple.

A jet engine is basically the simplest gas turbine. As

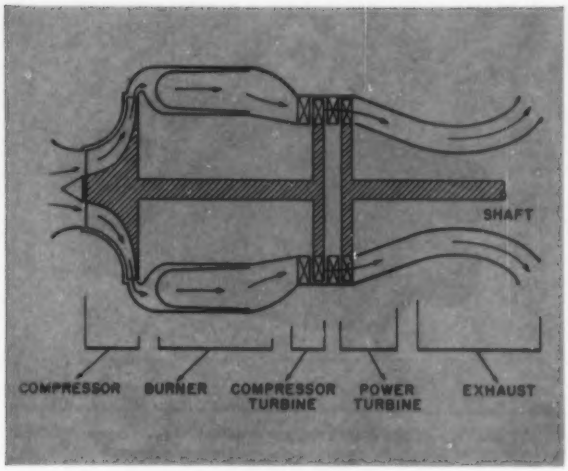


FIGURE 3—The two-shaft turbine is the most attractive type for automobiles.

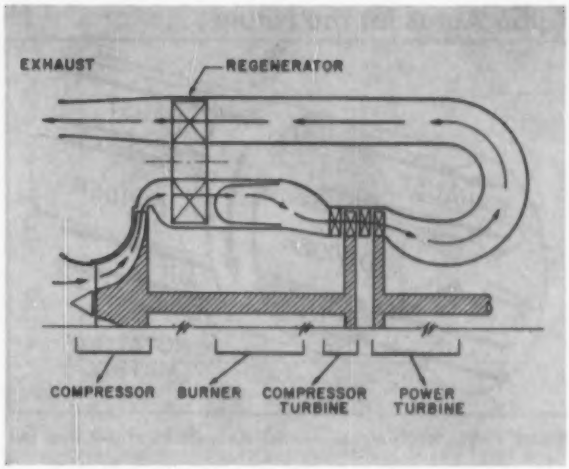


FIGURE 4—The regenerative turbine uses a heat exchanger to increase the efficiency of the engine.

shown in Figure 1, it consists of a compressor, burners or combustors, a turbine, and an exhaust nozzle. Air is compressed to 3 to 12 times its original pressure. The compressed air is heated by combustion of fuel in the burner. In the turbine, the hot gases expand just enough to drive the compressor. Further expansion in the exhaust nozzle accelerates the exhaust into a high-speed jet. Reaction to that acceleration is the only useful output of this type of engine. Jets are effective and efficient for propelling high-speed aircraft, but they are not practical or efficient for land vehicles, which need to have power transmitted through a rotating shaft.

A single-shaft turbine, as shown in Figure 2, employs a larger turbine to extract more work from the hot gases; this extra work is delivered through an output shaft and a set of gears. The turbine rotates at 15,000 to 50,000 revolutions per minute, and the gears are used to reduce this high speed. The single-shaft turbine is being used successfully in turboprop aircraft and some air and gas compressors. They could be used to power land vehicles but would not be practical; turbines large enough to give adequate acceleration would be uneconomical at normal speeds and loads.

A two-shaft turbine is the most attractive type for vehicles. As shown in Figure 3, it has two small turbines instead of a large one. The first is directly connected to the compressor and extracts just enough power from the hot gases to drive the compressor and engine accessories. The second turbine absorbs as much as possible of the remaining power and delivers it to the output shaft. The two units are mechanically independent. The compressor and its drive turbine are free to run at optimum speed. The power turbine is geared to the wheels of the vehicle; its speed depends on the vehicle's speed and gear ratios.

The two-shaft gas turbine also acts as a torque converter. When the output shaft is stalled, torque is twice as high as at rated speed. This characteristic permits the gas turbine to replace the combination of piston engine and torque converter found in many of today's vehicles. However, it does not completely replace the transmission; the turbine needs a simple transmission with a reverse gear and at least two forward speeds. This transmission might be combined with the speed-reduction gears.

Contemporary two-shaft gas turbines are satisfactory in most respects for automotive use, but they have two outstanding disadvantages: they burn too much fuel and the exhaust is too hot. Regeneration reduces both shortcomings, which result from leaving too much energy in the exhaust.

A regenerative turbine, shown in Figure 4, uses a heat exchanger to transfer heat from the hot exhaust to the cooler compressed air. This arrangement reduces the amount of fuel that must be burned to heat the air; it also cools the exhaust. Heat exchangers in gas turbines are not new; the benefits and practicality of regeneration were demonstrated 17 years ago. However, conventional heat exchangers are too bulky to be practical in land vehicles. Also, gas turbines, to be efficient, must have heat exchangers of high effectiveness; because most of the available heat must be recovered, counter-flow heat exchange is desirable. The hot exhaust must heat air which has already been warmed, and the partially cooled exhaust should warm the cool air as it enters the heat exchanger. If simple cross-flow heat exchange is used instead of counter-flow, the effectiveness will be low, probably only 50-65 percent. Recent developments of apparently suitable, compact, counter-flow heat exchangers seem to open the way for the use of regeneration in automotive gas turbines.

One type, a rotary regenerator, as shown in Figure 5, is a disc-shaped matrix; it is designed to permit axial flow but prevent circumferential flow. As it rotates at 10 to 100 rpm, a section of it passes alternately through the hot exhaust-gas stream and the cooler compressed-air stream. Counter-flow heat exchange is easily achieved by having the air and exhaust flow through the matrix in opposite directions. Seals on the divider that separates the two streams keep the high-pressure air from escaping into the exhaust duct. The matrix is much finer than shown; spacings are about 0.030-inch. Such small passages are typical of compact heat exchangers. Rotary regenerators have two problems, (1) wear of the seals,

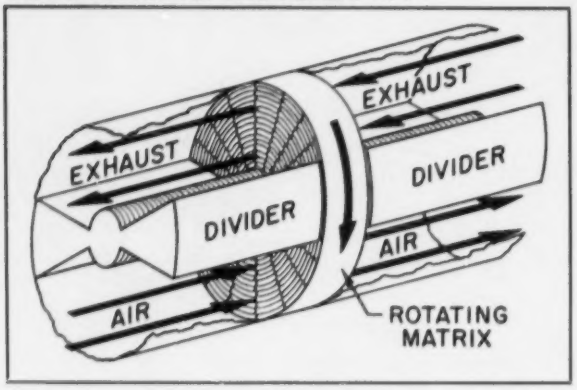


FIGURE 5—The rotary regenerator has the problems of seal wear and air loss.

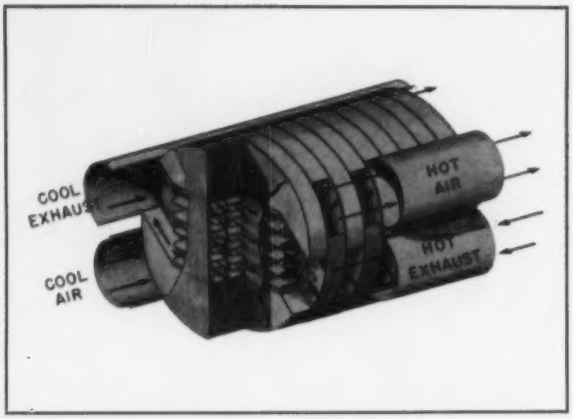


FIGURE 6—The recuperator is larger than the rotary regenerator but it has the advantage of no moving parts.

and (2) air loss, which is made up of leakage past the seals and carry-over of compressed air in the matrix.

A recuperator, which is another kind of heat exchanger, has no moving parts and does not have seal problems. The essential part is again a very fine matrix that facilitates heat transfer and controls gas flow. It must be combined with other design features that insure counter-flow heat exchange. In one type of counter-flow recuperator, the matrix is in the center, as shown in Figure 6. It is made up of a number of thin sections with fine corrugations. Exhaust flows through alternate sections; air flows through the others in the opposite direction. The arrangement of the diagonal passages that lead to the matrix keeps the exhaust and air separated so they may flow from and into separate ducts.

Recuperators may be slightly bigger than rotary regenerators and might become fouled more easily. However, ingenious arrangements could minimize size and the advantages of no moving parts and no air loss may outweigh the difference.

The component design of a turbine is varied to fit its application. Two-shaft turbines appear best for automotive uses, and in most applications heat exchangers will be desirable. In both respects automotive turbines differ from aircraft turbines. Important differences are also desirable in the design of the components—compressor, turbine, burners, and bearings.

In aircraft the axial compressor predominates because it is smaller in diameter, has slightly better peak efficiency, and is easier to compound to give high pressure ratios. For automotive gas turbines, centrifugal compressors are better because they are lighter, cheaper to make, and more efficient at part load and low speed.

To date, axial turbines have predominated in both aircraft and land gas turbines. However, centripetal turbines—sometimes called radial in-flow turbines—are being developed for automotive units. Centripetal turbines are essentially centrifugal compressors in reverse, and they appear attractive for the same reasons as centrifugal comperssors—lower cost and better part load efficiency. They also may run cooler and be less sensitive to thermal shock.

Aircraft turbines have 8 to 12 burners or an annular combustor with about 20 nozzles. Automotive turbines have only 1, 2, or 4 burners. Different fuel introduction systems are being developed and fuel flow and control systems must be simpler than the very expensive aircraft systems.

Aircraft turbines use ball and roller bearings to maximize mechanical efficiency. Automotive designers favor journal bearings because of lower cost and greater reliability; designers appear able to achieve these goals without too great a loss in efficiency.

FUEL ECONOMY

The fuel economy of the automotive gas turbine depends on both thermal efficiency and fuel cost. Efficiency is dependent on engine design parameters which may be optimized only at the expense of specific weight and volume, cost, and maintenance. Part-load efficiency is usually lower than full-load efficiency; and where part load operation predominates, the reduction is important. If an engine requires special, expensive fuels, fuel economy will be poor even though efficiency is high.

The effect of design parameters is being studied very closely. In a gas turbine, brake thermal efficiency depends primarily on the amount of compression, on the efficiency of the compressor and turbines, on the temperature at the turbine inlet, and on the use and effectiveness of a regenerator. Mechanical efficiency, combustion efficiency, and pressure losses are less important. The calculated brake thermal efficiencies in Figure 7 show the effects of compression, compressor and turbine efficiency, turbine inlet temperature, and regeneration, and the general levels of fuel economy that may be expected. The assumed conditions for the data in Figure 7 are given in Table 1.

Current experimental automotive gas turbines use about 1500 F. turbine-inlet temperature, and achieve 80 percent compressor and turbine efficiency. With these values and no regenerator, thermal efficiency increases from zero, at no compression or a 1:1 pressure ratio, to a maximum of about 18 percent, at 7:1 to 8:1 pressure ratio. The high-pressure-ratio engines are also more

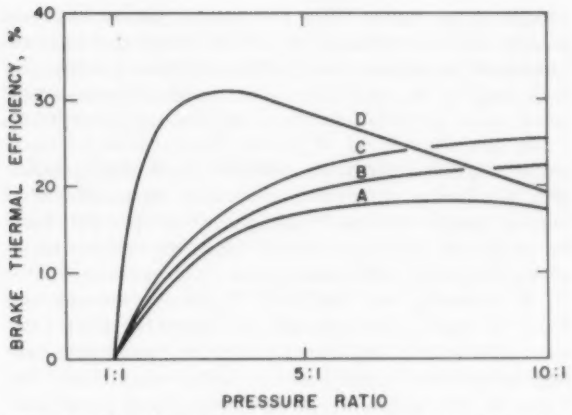


FIGURE 7—The design of the turbine can have an appreciable effect on the efficiency. The design of the turbines represented in this figure is given in Table 1.

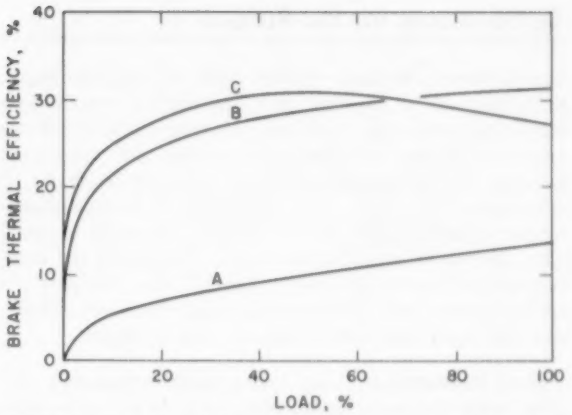


FIGURE 8—The effect of load on efficiency can be varied by turbine design. The design of the turbines represented in this figure is given in Table 2.

TABLE 1
Key to Figure 7

Curve	Turbine Inlet Temperature, F.	Compressor and Turbine Efficiency, Percent	Regenerator Effectiveness, Percent
A	1500	80	None
B	1800	80	None
C	1500	85	None
D	1500	80	90

TABLE 2
Key to Figure 8

Curve	Pressure Ratio at Full Load	Regenerator Effectiveness, Percent	Nozzles	Compressor and Turbine Efficiency, Percent	Turbine Inlet Temperature at Full Load, F.
A	3.5:1	None	Fixed	80	1500
B	3.5:1	90	Fixed	80	1500
C	6:1	90	Variable	80	1500

powerful, but they are heavier and more expensive.

If better materials or blade cooling permit the turbine inlet temperature to be raised from 1500 F. to 1800 F., thermal efficiency and optimum pressure ratio are raised. The higher temperatures also improve the power of the engine. However, the better materials or blade cooling increases the cost of the engine.

Increasing compressor and turbine efficiencies from 80 percent to 85 percent increases thermal efficiency about one-third and raises the optimum pressure ratio. It also makes the engine more powerful. However, more efficient compressors and turbines are more difficult and expensive to design and build.

Today, good regenerators are 80 to 90 percent effective. Addition of a 90 percent-effective regenerator to a gas turbine increases efficiency markedly, especially at pressure ratios of 2:1 to 4:1. It also reduces the optimum pressure ratio to about 3.5:1. As with the nonregenerative cycle, this optimum pressure ratio increases with turbine inlet temperature. Optimum pressure ratio is higher if the regenerator is less effective.

Part-load economy is often more important than full-load economy. Part-load economy depends on the means of reducing power. Power can be reduced by slowing the engine; that reduces air flow and pressure ratio and consequently lowers efficiency. Power can also be reduced by lowering turbine inlet temperature; that too lowers efficiency. Actually, some combination of the two is used.

A comparison of the efficiencies of different engines may be made by referring to Figure 8. The assumed operating conditions are listed in Table 2. For an engine which has a 3.5:1 pressure ratio, and 1500 F. turbine inlet temperature at full load, and 80 percent efficient compressor and turbines, thermal efficiency is about 13 percent at full load and drops steadily as load is reduced, as shown in Figure 8. The same engine with a regenerator would have better economy at both full load and part load.

Detailed comparison shows a further advantage for regeneration. True, it doubles economy at full load. But at about 10 percent load, where automobiles operate most of the time, it improves economy almost four-fold. Thus in applications where part load economy is important, the regenerator is particularly attractive.

If temperature were maintained at part load, the compressor and its turbine would accelerate; temperature is reduced to prevent speeding up. However, if a variable nozzle were used on one turbine, temperature could be maintained without the speeding up, and part load economy would be improved. Higher pressure ratios would also be feasible and improved part-load economy could be achieved, but at the expense of some reduction at full load.

Fuel quality and cost information is vague because experience with different fuels in automotive gas turbines is limited, especially in regenerative units. The automotive gas turbine is not omnivorous. It will not operate satisfactorily on residual fuels because they contain ash that forms troublesome deposits on the turbines and, if there is one, in the regenerator. At the other extreme, propane would be a satisfactory fuel technically, but the high-cost fuel system which limits its usefulness in reciprocating engines also limits its applicability to gas turbine vehicles. Because turbines do not knock, there will be no need for high-octane fuels or tetraethyllead. On the other hand, some fuels form carbon deposits and turbine-fuel quality must be controlled enough to prevent this. Fuel systems, too, will impose fuel-quality limitations.

GAS TURBINES VS. RECIPROCATING ENGINES

A comparison of gas turbines with gasoline engines or

diesels should be made on the basis of complete power units and not of bare engines. The turbine requires less auxiliary equipment; so it has advantages which are not apparent unless complete power units are compared. Because the gas turbine acts like a torque converter, it eliminates the weight, cost, and losses of a conventional torque converter in a car or the extra gears in a truck. The absence of a cooling system also improves the competitive position of turbines when installed, because the cooling system of a reciprocating engine increases weight, size and cost, and reduces power and economy.

Fuel economy is a big factor when comparing turbines with reciprocating engines. The current nonregenerative turbine does not approach the thermal efficiency of either the gasoline engine or diesel. If higher turbine inlet temperatures and more efficient compressors and turbines are used, nonregenerative gas turbines of 6:1 to 8:1 pressure ratio would approach gasoline engine economy. A regenerative turbine with current efficiencies and 3:1 to 4:1 pressure ratio could be competitive with gasoline engines; and with higher temperatures or efficiencies, it might be better than gasoline engines and competitive with diesels. Nonregenerative turbines suffer the greatest loss in economy as load is reduced. Regenerative turbines and gasoline engines are about equal and diesels are the best in this respect. Installed in a vehicle, the turbine should appear comparatively more economical because it has less transmission losses and no fan losses.

The use of heavier and cheaper fuel will also aid the turbine in comparison with the gasoline engine. When the turbine fuel envisioned now is marketed extensively, its cost could be just below that of regular gasoline. Turbine fuel would be heavier and the greater heat content of a gallon would benefit turbines about 5 percent more on fuel expense. Thus the gas turbine is about 8 percent ahead of the gasoline engine to start with. It does not have these advantages over diesels and probably would be at a disadvantage.

Low weight is the outstanding advantage of the gas turbine. A nonregenerative turbine weighs about one pound per horsepower; that is only one-fifth as much as gasoline engines and one-twelfth as much as high-speed diesels. A regenerator about doubles the weight of the turbine and halves the advantage. However, the regenerative turbine is much lighter than reciprocating engines. Reduced transmission requirements and absence of a cooling system increase this advantage in vehicles.

Small size is a lesser advantage of the turbine; the advantage over diesels is greater than that over gasoline engines. A regenerator decreases the advantage of the turbine, but a simpler transmission and no radiator increase the advantage. The turbine allows more freedom in the shape of the power plant and that freedom may be important in automobiles or earthmovers.

The big unanswered question is, "How much will it cost to build a gas turbine?" Any cost comparison should be made at equal production rates, because quantity has a great effect on cost. The turbine is smaller, lighter, and has fewer parts, so it should be cheaper than reciprocating engines. This cost-weight relation has been true for aircraft engines. One builder found that in equal quantities jet engines cost slightly less than gasoline aircraft engines of about the same weight. Consequently, being more powerful, turbines cost less per horsepower.

On the other hand, if turbine blades must be made out of expensive alloys, cost will be raised. Also, production of alloying metals is limited and the possibility of finding enough for 8 to 10 million turbines per year must be considered. With one present alloy, the scarcest metal would be nickel, with turbines taking 80 percent of 1950 U. S. consumption. This is a significant amount and would certainly affect markets and prices but it does not seem absolutely prohibitive. Cheaper and more-abundant high-temperature materials are being sought and that seems the desirable and probable route. Some possibilities are boron and molybdenum alloys, and certain oxides and carbides. The oxides and carbides tend to be brittle but this may be less of a problem in automotive units than in aircraft engines. Blade coatings are also possibilities.

In cost, too, the simpler transmission requirements are an advantage for the turbine although the high-speed-reduction gears could offset this advantage. Over-all, the turbine appears to have a possible cost advantage.

Less maintenance will be required for the gas turbines but the maintenance that is required will necessitate new equipment and techniques. Trained personnel will be needed.

Regular day-to-day maintenance should include the use of less lubricating oil and fewer oil changes, the absence of need for antifreeze, flushes, and fan belts, and a reduction in tune-ups and checks of spark plugs and points or injection systems. On the other hand, some type of fuel system must be used, and it will require servicing.

Major overhauls could be less frequent. When they occur, the lightness and simplicity of the turbine should simplify and speed the job. Conversely, because of the very high rotative speeds, balance will be important. Also some types of turbine metals require replacement on a time schedule rather than only when there are outward signs of distress. For fleets, this might fit into scheduled maintenance very well, but for most automobile owners it would be a new way of doing things. The regenerator might add to maintenance problems; cleaning or replacement would be necessary when effectiveness dropped or when pressure drop became too high.

Noise and vibration are other factors to consider. Although unmuffled turbine engines can emit a high-pitched noise, this noise is no greater than that of an unmuffled reciprocating engine operating at full power. The noise can come from compressor inlet, turbine outlet, or highly-loaded high-speed gears. Due to the high pitch, the noise is easier to muffle than the noise from reciprocating engines; so turbines should be quiet if both intake and exhaust are fitted with silencers, and if gear noises are minimized or absorbed.

Because there is no reciprocating motion, turbines are much smoother than reciprocating engines. This reduction in vibration has been apparent in the applications made to date.

Exhaust from a gas turbine should be cleaner than

that from either a diesel or gasoline engine. It should not form smoke like a diesel or emit carbon monoxide or incompletely burned fuel like a gasoline engine. Nevertheless, poor combustor design and the use of poor fuel could cause smoke or odor.

The safeness of turbines is frequently mentioned in connection with "searing" exhaust and "flying apart" of the turbine wheel. At the engine, turbine exhaust at 400 F. regenerative and 1000 F. nonregenerative is cooler than gasoline engine exhaust at 1200 to 1400 F. But, because there is less of the gasoline-engine exhaust, it cools faster in the exhaust pipe and is cooler at the outlet than the exhaust of a nonregenerative turbine. The exhaust of the regenerative gas turbine is quite cool, however, and is not a problem.

Turbines would come apart if run too fast and the power turbine will accelerate rapidly if unloaded. However, it will not exceed twice normal operating speed, and if designed for this speed it should be quite safe. Even if a failure occurs, it is not the major castastrophe sometimes envisioned.

The temperature sensitivity of gas turbines is greater than that of reciprocating engines and in most cases this temperature sensitivity is a disadvantage. A turbine loses 15 to 20 percent in power if ambient temperature is increased from 60 F. to 120 F. This loss is 2 to 3 times as great as the loss suffered by gasoline or diesel engines. The difference would be less if an 1800 F. turbine were used instead of a 1500 F. one. On the other hand, a turbine gains more in power at low temperatures, and in some applications this could be an advantage. Fuel consumption is also better at low temperatures.

In starting, the gas turbine has one advantage and one disadvantage. At idling speed, the turbine has more inertial energy than reciprocating engines. Therefore a bigger starting motor is required or a longer cranking period. Starting can take as long as 15 seconds. On the other hand, the engine is ready to deliver full power as soon as it is running. Because of the lightness of the parts, a long warm-up period is not required. The turbine will start at much lower temperatures than reciprocating engines; that can be important in cold climates.

The throttle response depends on the relation of horsepower to speed. Neither the gas turbine nor the gasoline engine exactly meets the level-road-horsepower requirement of an automobile at all speeds, as shown in Figure 9, and differences in throttle response are based partially on the way the engines are adjusted to meet this requirement. At intermediate engine speeds the gasoline engine can produce much more power than is required. The horsepower is reduced by throttling, so a large reserve of power is available almost instantly when the throttle is opened.

With the gas turbine, the available horsepower is much closer to the horsepower requirement and there is little reserve for acceleration. Also, it is not practical to throttle a gas turbine; with the much greater air flow in this type of engine, throttling imposes severe penalties on fuel economy. Therefore, the speed of the compressor section of the turbine is lowered to reduce horsepower to the road requirement. The torque-converter characteristics of the two-shaft turbine adjust for the small difference in speed. Horsepower may also be reduced by lowering the turbine inlet temperature; however, this requires variable nozzles and, even with them, can only be done to a limited extent because it reduces economy. When the driver depresses the accelerator to get more power, the compressor and its turbine must accelerate to produce it. This takes time. Delays of 5 to 15 seconds are experienced in current units between idle and full horsepower. However, the delay from part throttle to full horsepower is much shorter. If the gas turbine is to become acceptable for passenger cars, the delay between idle and full horsepower must be reduced to 1 or 2 seconds by reducing rotor inertia, increasing turbine inlet temperatures during acceleration, or raising idle speed. The gas turbine cannot be expected to surpass the gasoline engine in throttle response but will probably approach it closely enough to be acceptable.

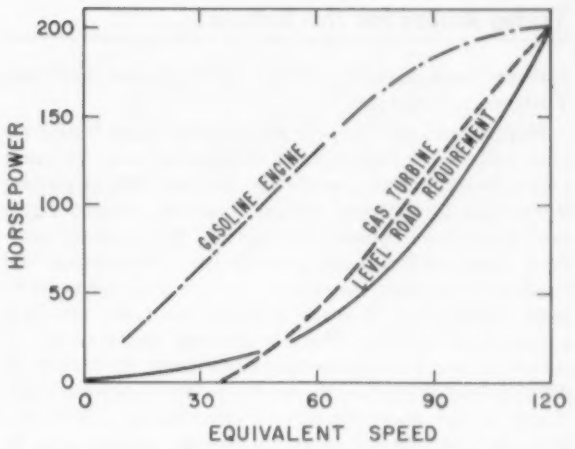


FIGURE 9—The horsepower available from a gas turbine is so close to the horsepower requirement of an automobile that there is little reserve for acceleration.

APPLICATIONS AND INTRODUCTIONS

Over-all, the turbine has promise; but plenty of development work remains to be done, especially on details and manufacturing. How soon gas turbines become available in various commercial applications depends on the intensity of development effort. Development work is being done and some developments have been unveiled. The turbine seems to be moving ahead, although the status and outlook in each industry are different. In the sense that automobiles take the greatest number of engines, they are of greatest importance. Also, because of the effects of fuel supply, a change-over, once well under way, would probably be completed quicker. Some of the opportunities for the turbine in other applications are given in the accompanying box.

Regenerative gas turbines seem to be the best type for automobiles because of their better part-load economy. Chrysler has one in a Plymouth; it has been driven on the streets and highways of the midwest and in March, 1956 was driven from New York to Los Angeles. General Motors has unveiled the Firebird II, a four-passenger "dream car"; it is powered by a regenerative gas turbine. Ford has published several papers on its gas-turbine development. Packard is also working on

Turbo Autos for the Future . . .

turbines for automobiles as are Rover, Austin, Fiat, and Turbomeca in Europe.

Novelty and sales appeal are inviting plums luring the auto builders to market turbine-powered cars. An easier engine to style around and even the possibility of putting the engine in the rear without upsetting weight distribution are other possible advantages. On a more mundane basis, turbines can provide less maintenance and smoother operation. Even now, fuel economy seems to be good enough that it is not a major deterrent, and it is expected to improve. Throttle response and a means or substitute for braking-on-the-engine need the benefit of development, but should not be major problems. This leaves as the major factors in introduction initial cost and the development of manufacturing techniques to make cost reasonable. If gas turbine automobiles are to be anything but a novelty, they must be about as cheap or cheaper to build than gasoline-engined automobiles. Any extra engine costs must be offset by permitted savings on the cost of transmission, radiator, frame and/or running gear.

With so many companies working on it, development should be fairly rapid. It should lead to the introduction of turbine-powered cars in the next decade. A European sports car with a gas turbine is expected in the next year or two. In the U. S., introduction will probably be a little later—about 1960. A special car like a Thunderbird or Corvette appears to be the most likely place; volume is low, and price is of secondary importance. Several years of experience with such units in the public's hands should prove or disprove gas-turbine autos and allow time for further manufacturing development. Until then, it will not be possible to determine with certainty whether gas turbines will replace gasoline engines in automobiles.

If the turbines prove best it will take several years of "tooling-up" before large-scale introduction can take place. Even then it will take several years for change-over and the production of cars, so it appears reasonable to guess that, even being optimistic, it will be about 1970 before there will be turbines in as many as 10 percent of the cars on the road. After 1970, build-up could be rapid. ##

Meet the Author

LAMONT ELTINGE recently completed a M.S. degree in mechanical engineering at Illinois Institute of Technology. A graduate of Purdue University, he has been with Standard Oil Company (Indiana) since 1951, and he is now a group leader in the company's Automotive Research division, with responsibilities for research in diesel and turbine fuels. He is author of a number of articles on gas-turbine and diesel fuels.

Here are some other applications which may usher gas turbine into prominence

• **Portable Power**—Boeing, Solar, and Continental are building turbines that will be useful in a number of miscellaneous applications like fire pumps, air compressors, stand-by service, and special vehicles. Some others in the field are AiResearch in this country, Blackburn and Rover in England, and Turbomeca in France.

The current deterrent to introduction is cost. A 50-hp engine costs about $5000 and a 200 to 500-hp turbine costs $20,000 to $70,000. If production is increased, price should fall and commercial application should begin. This introduction could be spurred by any company's decision to start volume production. The next 3 to 5 years may see the commercial introduction of special gas turbines and sales of several thousand annually.

• **Off-Highway Equipment**—In off-highway equipment, there seems to be a need for more power. The two-shaft unit is attractive, and its torque converter characteristics would make it a natural for a booster power plant. Other characteristics that appeal to the equipment designers are the potentially lower cost, ability to digest dirty air, and improved visibility. Nonregenerative turbines seem most interesting, and their other advantages may outweigh the deterrent of poorer fuel consumption.

At least three of the major builders of off-highway equipment are developing gas turbines, and many engineers feel that this part of the automotive industry may be the first to use turbines. Introduction in 3 to 5 years is possible.

• **Railroad Locomotives**—Gas turbine locomotives are currently in everyday service on the railroads. The Union Pacific is operating 23 G. E. gas-turbine locomotives of 4500 hp and has ordered or optioned 45 more of 8500 hp. Other gas turbine locomotives are operating in England and Switzerland. The U. P. units are nonregenerative and are used in heavy-duty mountain operation so that they run near full load where their efficiency is best. For light load or idle, the turbine is shut down and a diesel is used.

A peculiar and important feature in the U. S. railroad picture is the recent change to diesel-electric locomotives. Most are less than 10 years old and no one knows how long it will take to wear them out.

While complete scrapping of locomotives would be expensive, a change of engines in the same car body would only cost about 20 percent as much and appears more probable. Replacing the standard 1500 to 1750 horsepower diesel engine with a 3000 to 4000 horsepower gas turbine would be one way of upping locomotive power and might be attractive in some cases as train speeds are increased.

• **Trucks and Buses**—The Boeing-Kenworth truck and General Motors' Turbocruiser bus are examples of gas turbines in highway trucks and buses. Both had two-shaft nonregenerative units. They were satisfactory in most respects except fuel consumption. A regenerator seems desirable although not absolutely necessary. With trucks up against weight and length laws, the turbine means more payload and profit. A simpler transmission adds to payload and means less driver fatigue; in mountainous operations, the chance to shift into reverse and use the turbine as a powerful dynamic brake is attractive. Braking on the compressor is another possibility. Less maintenance and a non-smoky exhaust are added advantages. For these applications initial cost must be reasonable.

It seems the turbine may find some special applications in the truck field in as little as 3 to 5 years. However, a general change-over will require turbines that will take longer to develop and the change-over will be slow. Light truck applications may well follow automobiles.

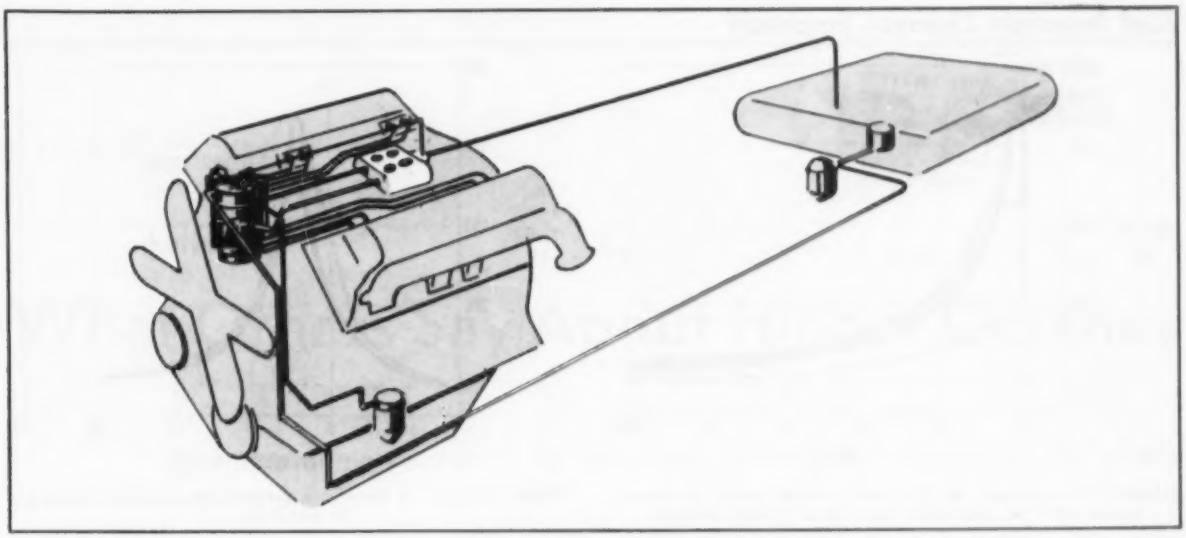


FIGURE 1—Fuel injection adds a new element of control to the burning process of an internal combustion engine.

Higher Octanes or Not

Fuel Injection Changes Emphasis

This development in engine design indicates that the emphasis in motor fuel quality will shift from octanes to volatility.

A. E. Cleveland
Ford Motor Company
Dearborn, Michigan

MUCH IS BEING written and said about gasoline injection. It is a logical development, not so much for what it does, but for the new avenues of engine design that will be opened by successful application by a mass-produced and economical fuel injector. In all probability, the first popular fuel injector will be the one which in performance most nearly resembles the carburetor, and it is doubtful whether at first it will show any great or radical improvements over the carburetor. However, increased familiarization with the equipment by the public and the adaptation of mass production techniques with consequent savings will soon permit advances in injector design and in the engines to adapt them to injector operation. These advances will produce results worthy of the engineering time and effort spent in the development. A fuel injection system is shown in Figure 1.

Nor will that be the end. New combustion chambers can be designed around injectors. With fuel injection, a new element of control is introduced into the burning process, and where the ultimate end of developments centered on controlled burning may be, it is impossible at this time to predict. We can say that some laboratory work has shown remarkable possibilities for improved thermal efficiency as well as complete octane insensitivity with controlled burning. However, don't expect this the year after the injector is first introduced. It is the ultimate end-result of a long breed of developments, all of which must have public acceptance and meet the requirements of mass production techniques, and any one of the developments may become the end of its breed.

Another possible line for engine development is in the burning cycle itself. We call the present conventional gasoline engine the Otto-cycle engine and contrast it with the diesel-cycle engine. This is because the combustion is supposed to occur at constant volume as in the cycle proposed by Mr. Otto (Figure 2) and not at constant pressure as in the cycle proposed by Mr. Diesel. Well, of course, nothing is perfect, and the gasoline engine isn't operating on constant volume combustion (Figure 3), and the Diesel not on constant pressure. There is a lot that can be accomplished by a thorough study of the combustion chamber and the possible shapes in conjunction with the timed valve fuel feed and ignition events that control combustion. It is possible that the end result of such studies may be more rewarding than the gas turbine, particularly because it can be brought about with fewer changes in parts and in a shorter period of time. Any change along this line would retain the present horsepower breed as represented by the torque-speed curve relation, but it might prove to be a much less octane-critical feeder.

Now as to fuels and fuel systems. All of the items dis-

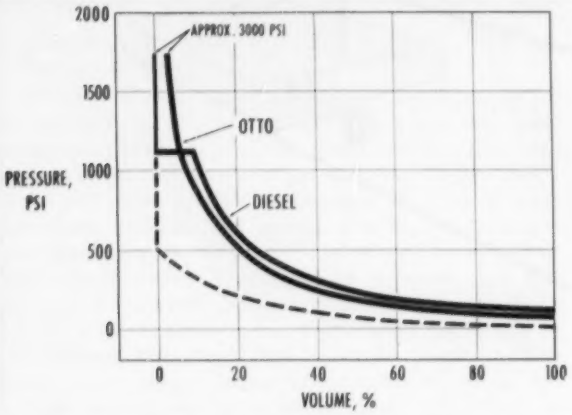


FIGURE 2—Theoretically, the Otto-cycle produces energy at constant volume while the diesel-cycle does this at constant pressure.

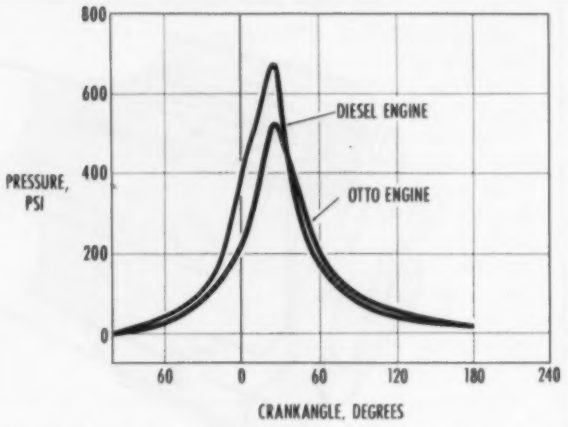


FIGURE 3—Here is a comparison between the actual Otto-cycle and the diesel-cycle.

cussed will have a possible effect on the fuel requirements of the passenger car of the future. It is to be emphasized that the time—requirement of each of these possible developments is proportional to its departure from the conventional. Therefore, fuel injection, with performance characteristics similar to the conventional carburetor, is apt to precede throttle-less engines; and many lines of conventional reciprocating engine developments will precede the adoption of a radically new engine such as a gas turbine. It is, therefore, not probable that the change in fuel requirements will be a sudden one. Of the possible developments that may affect fuel requirements for future cars, several are designed to cut down the octane sensitivity of the engine. By that I mean not just an improved ability to appreciate commercial type fuels, but the ability to operate at increased compression ratios on fuels of substantially the same or lower octane numbers.

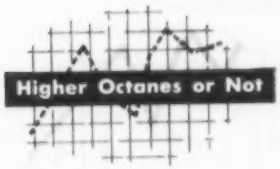
Fuel injection systems, although equipped with many more devices, such as pressure fuel supply systems, vapor bleed systems, and vapor separators, are still fundamentally much more vapor critical than the carburetor, and fuel volatility will have to be watched more closely in injector equipped cars than in carburetor equipped cars. Larger engines also mean more rejected heat, and there appears little relief from the crowded engine compartments dictated by styling trends and increased accessories. In short, it is probable that in the car of the future, volatility characteristics of the fuel will be a more important and more competitive quality than will octane number. I say this because there are immediate as well as possible future design trends which will tend to minimize the detonation problem but will increase the importance of the effect of low boiling point volatility. For example, larger engines mean fewer wide-open-throttle accelerations, with consequently less severe detonation; however, larger engines mean more crowded engine compartments and higher under-hood temperatures. Higher under-hood temperatures result in higher pressures for the same fuel volatility, with increased tendency to vapor lock and hot-starting difficulties.

Lower hood lines make for improved styling, better driver visibility, and last but far from least, increased customer demand. Lower hood lines however, mean crowding the air cleaner down over the carburetor, cutting down on the under-hood air, with increased congestion of parts. This also means less heat removed and higher under-hood temperatures with the resultant volatility problems. This lowered-hood trend also increases octane requirements slightly because of the increased intake-air temperatures. However, it is not nearly as critical to octane number requirement as it is to volatility, due principally to the fact that octanes are a factor only to a running engine and a moving vehicle. Volatility problems are most severe in a vehicle stopped after a period of hard running. In the one case, moving air is available to minimize the problem. In the other, the heat builds up and boils the fuel from the lines.

Projected developments in the immediate and more distant future all tend to magnify the problems connected with the handling of low-end high volatility. Many of these developments, on the other hand, tend to decrease the importance of detonation control, or octane numbers. We might safely conclude, therefore, that in the future we should give more cooperative attention to the study of techniques and a technical language for volatility than we give to a study of octane numbers. ##

Meet the Author

A. E. CLEVELAND was graduated from the University of Michigan in 1935. After that he held various engineering posts with the Oldsmobile division of General Motors Corporation until 1941, when he entered the Army's Motor Transport division. He left the service in 1946, as a lieutenant colonel in the Ordnance department. He started with Ford Motor Company in 1947 as a project engineer, rose rapidly to become supervisor of the Engine section of the Research department and since 1951, has been experimental-engine engineer.



What Others Say About Higher Octanes

Here are some comments by two other authorities concerning the recent engine developments.

G. J. Huebner, Jr.
Executive Engineer
Chrysler Corporation
Detroit

THE COMMENTS which we have to offer are more in the nature of picking out small details rather than any general criticism. Most of the points (in the preceding articles) are so well covered that no comment is necessary. In Cleveland's article entitled Fuel Injection Changes Emphasis, one thing might be added which may change the conclusions slightly. One of the effects of fuel injection would be to allow increases in volumetric efficiency of the reciprocating engine. Even with no further increase in compression ratio the effect would be sufficient initially to probably indicate the need for higher octane fuels because of a denser charge in the cylinder. Of course, Cleveland's other comments about large size engines requiring less wide-open throttle is still applicable, but other things being equal for two otherwise identical engines, a well engineered fuel injection system could necessitate a higher octane requirement.

In addition, highr octane fuels will certainly be even more available in the near future. Since the fuel is or will be available, the tendency of automotive engineers to take advantage of their opportunity to increase compression ratios could easily continue.

Cleveland's comments on fuel volatility with respect to injection systems are quite true. The injection system is not a cure-all which will allow higher fuel volatility and, in fact as he points out, may mean the reverse.

Eltinge's article on gas turbines is excellent background information. We cannot quite agree with him in his conclusions that the two shaft turbine needs two forward speed changes. We actually do not know, but there is a strong possibility that only reverse and direct will be needed.

I think that Eltinge has been a little bit rough on the nickel problem. He has picked one alloy which has been publicized by one research group and points out that this would take 80 percent of the 1950 U. S. consumption. This seems to be an unfair inference since it would obviously be impossible to manufacture large quantities of turbines on that basis, and no serious consideration should be given toward the use of an alloy such as this and other critical materials in quantities. He is quite correct in pointing out that much work is being done on metallurgical problems on gas turbines, and we might add that much progress is being made.

In regard to comments on noise and vibration, Eltinge has not noted that the regenerator is a superb exhaust silencer so that the problem of silencing the turbine is thereby substantially reduced.

F. C. Mock
Director of Fuel Systems Engineering
Bendix Products
South Bend, Indiana

WE ARE RATHER firmly convinced that fuel injection will not greatly change the octane requirements for present automobile fuels.

It will appreciably increase the horsepower at high speed, be somewhat beneficial as regards over-all fuel economy, and permit a great reduction in exhaust air pollution and unpleasant smog effects.

As Cleveland points out, fuel injection systems tend to be somewhat more affected than the carburetor by high volatility fuel; however, the corrective steps in fuel systems that we would have had to make with carburetor installations anyway will also meet this problem with injection.

Much greater improvement will be given by fuel injection on large truck and bus engines than on passenger car V-eight equipment, where short compact manifolds and automatic transmissions make carburetion relatively simple.

The automobile gas turbine is at least five years away. On account of its tendency toward high fuel consumption any sign of shortage in domestic petroleum supply could further postpone its use.

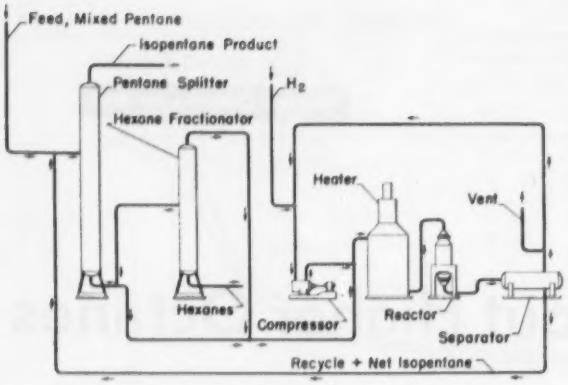


FIGURE 1—The Penex process isomerizes a mixture of pentanes and increases the clear octanes over 11 numbers.

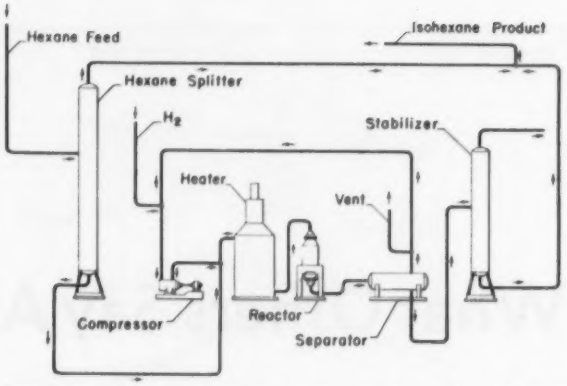


FIGURE 2—The process may be operated on a once-through or a recycle basis. Here hexanes are isomerized once-through.

Isomerize C_5 and C_6 With Penex

IN THE PAST pentane and hexane fractions have been thought of as being of good motor fuel quality. However, at the octane levels faced in the near future, an inspection of Table 1 indicates that there are a number of compounds whose use should be minimized due to their low octane ratings.

Universal Oil Products Company has recently announced the availability of the Penex process, which can readily upgrade low octane pentane and hexanes by isomerization. High yields of liquid products are obtained by catalytic processing at mild operating conditions and without catalyst regeneration. The reaction is carried out in the presence of hydrogen, but with most feeds the consumption or production of hydrogen is insignificant, and the small net purge requirement can be supplied from reforming units.

Figure 1 is a flow diagram of a Penex unit for recycle processing mixed pentanes.

The pertinent results from such processing of pentanes in a Penex unit are shown in Table 2.

The flexibility of the Penex process makes it possible also to process hexane fractions in a manner to meet the specific needs of the individual refiner. A simple Penex plant for once-through processing of hexanes is shown in Figure 2. In Table 3 are given yield and octane data typical of this processing procedure.

Addition of an aromatic separation step makes it possible to convert the hexanes to high octane isomers and the naphthenes to benzene, giving a total product of leaded research octane in excess of 100. In Table 4 are given data on such an operation.

This article condensed from a paper by H. W. Grote of Universal Oil Products Company, Des Plaines, Illinois. Original presentation was before the Pennsylvania Grade Association Meeting at Bradford, Pennsylvania, on June 13, 1956. ##

TABLE 1
Octanes of Hydrocarbons in Pentane-Hexane Boiling Range

COMPOUND	Boiling Point, °F.	Research Octanes	
		Clear	+3 cc.
Isopentane	82.1	92.3	103.5
Normal Pentane	96.9	61.7*	85.0*
Cyclopentane	120.7	100.2	101.4
2,2,Dimethylbutane	121.5	91.8	104.3
2,3,Dimethylbutane	136.4	102.6	107.8
2 Methylpentane	140.5	73.4*	93.1*
3 Methylpentane	145.1	74.5*	93.5*
Normal Hexane	155.7	24.8*	65.3*
Methylcyclopentane	161.3	91.3	103.8
2,2,Dimethylpentane	174.6	92.8	103.3
2,4,Dimethylpentane	176.9	83.1	96.6
Benzene	176.2	105.0	112.
Cyclohexane	177.3	83.0	97.4
2,2,3,Trimethylbutane	177.6	107.2	110.

* Undesirable for super quality motor fuels.

TABLE 2
Penex Processing of Pentanes

	Feed, Mixed Pentanes	PRODUCTS		
		Isopentane Fraction	Hexanes and Heavier	Total Product Liquids
Yields, Volume %	100.0	93.0	6.0	99.0
F-1 Octanes:				
Clear	79.2	91.3	83.1	90.9
+3 cc. TEL/Gal.	95.2	102.8	96.8	102.7
R.V.P., psi	18.2	21.7	12.4	21.1

TABLE 3
Once-Through Processing of Hexanes

	Feed, Mixed Hexanes	Hexane Splitter Overhead	Stabilized Reactor Effluent	Total Product Liquids
Yields, Volume %	100.0	42.5	54.5	97.0
F-1 Octanes:				
Clear	62.0	78.8	71.0	74.4
+ 3 cc. TEL/Gal.	85.0	96.0	92.0	93.8
R.V.P., psi	6.1	7.5	7.5	7.5

TABLE 4
Recycle Processing of Hexanes With Aromatic Extraction

	Feed, Mixed Hexanes	PRODUCTS		
		Non-Aromatics	Benzene	Total Liquids
Yields and Concentrations, Vol. % of Feed:				
Cyclopentane	6.1	6.1	.....	6.1
Hexanes	67.1	63.7	.....	63.7
Methylcyclopentane	9.7	.....	.....	.....
Cyclohexane	7.1	.....	.....	.....
Benzene	10.0	.....	23.5	23.5
	100.0	69.8	23.5	93.3
F-1 Octanes:				
Clear	69.7	84.0	100.0*	88.0
+ 3 cc. TEL/Gal.	90.2	98.5	108.0*	100.8

* Some non-aromatics present.

Part 4

Automation Today

System instability is a problem in the application of automatic control. Here are some graphical methods for predicting and correcting process instability.

Theodore J. Williams
USAF Institute of Technology
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IN THE PREVIOUS article we have shown the influence of the various types of controller action upon the dynamic equations of relatively simple linear processes. From this we postulated the physical effect of the controller upon the process in question. At that time the problem of system instability was mentioned as a limiting factor in the application of automatic control to a petroleum or chemical process. Now we will investigate some graphical methods of predicting and correcting process instability.

DETERMINE PROCESS STABILITY

There are two basic methods for determining the *response* of a physical system to an external source of error or upset and, along with this response, the *stability* of the system when subjected to this upset. By response and stability we specifically mean: how rapidly does the system react to the upset; what is the shape of a graph of the output variable of the process versus time; and finally does the system eventually stabilize at some new operating point or is it forced completely off-specification with no hope of return to an acceptable operating point or condition?

These two methods, which will be discussed herein, are *transient response* and *frequency response*.[4] Both are important in the study of automatic control because of special advantages which are possessed by each one alone. These along with the particular disadvantages of each method will be given in this discussion.

Transient Response will be considered first. We have already considered the response of a multicapacity system when subjected to a step function, that is, a sudden permanent change in the input variable. This was shown in the curves given in Part 2 of this series. These curves turned out to be exponential functions whose general shape and slope were a function of the number and size of the time constants in the system. Curves of this type can be obtained for any postulated system by solving the differential equations of the system using the step function as the *forcing function* or input to the system in order to obtain the variation of the desired output variable of the process in terms of time, t.

Due to the nature of the mathematical representation of the step function, these resulting general equations must usually be solved by Laplace transform or similar

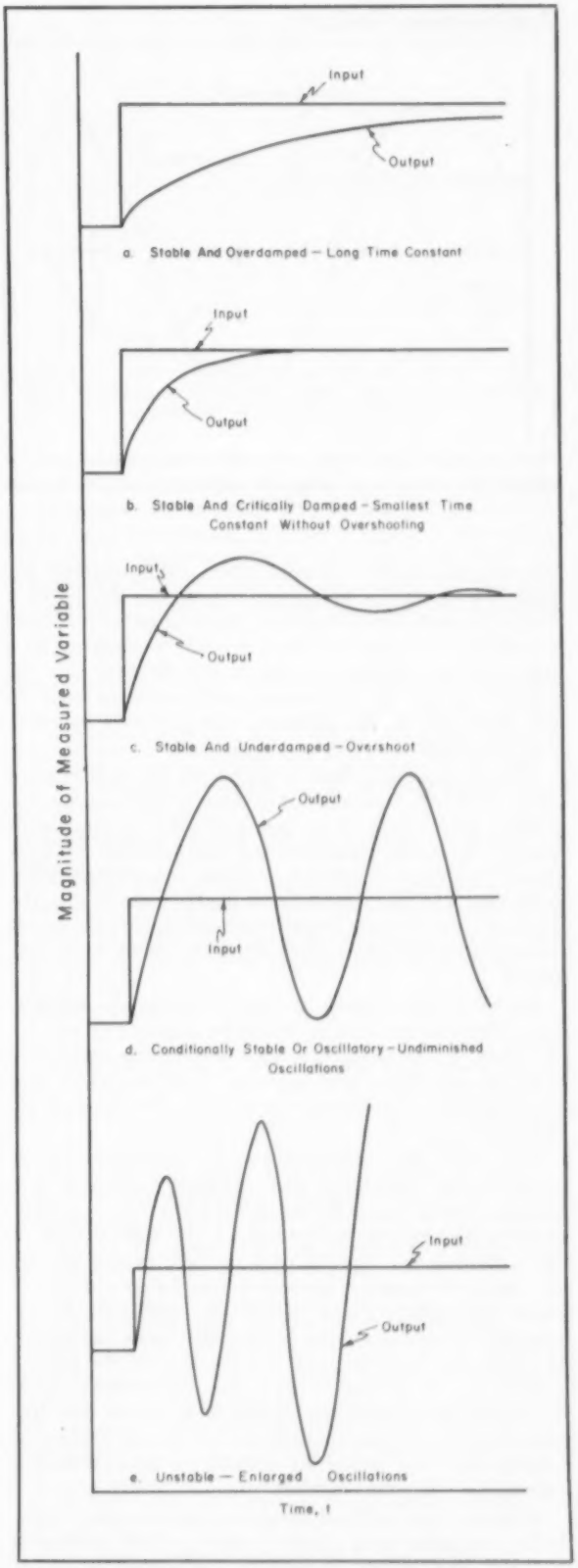

FIGURE 20—The transient response may range from very slow (a) to very fast (e). Some of the characteristic types of response are shown here.

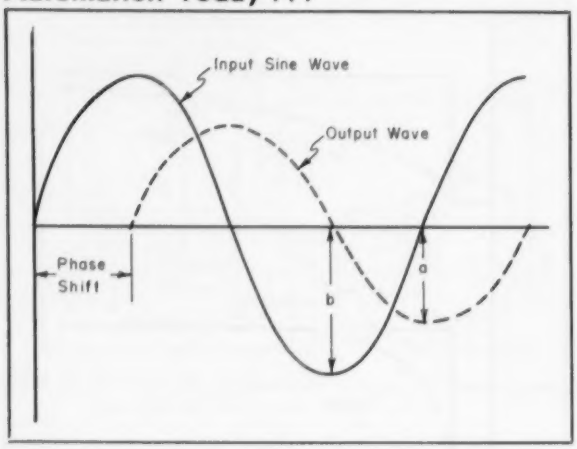

FIGURE 21—In frequency response, the magnitude ratio is the quotient of (a) divided by (b).

operational calculus methods when hand methods are used.[6] However, the equations for processes fitted with a feed-back loop and particularly those fitted with control equipment can only be solved by this method up to a relatively low degree of complexity. Beyond this the methods of the Laplace transform are unwieldy from the the sheer size of the algebraic manipulations involved. Then an electronic computer is necessary.

The response of a physical system to the step input is often obtained experimentally. This is particularly important in the case of an involved piece of equipment whose differential equations are too complex for even electronic computer solution or whose time constants are unknown. The step input can be readily simulated in the physical system by a rapidly opened valve, an on-off switch, or a sudden change in the set-point of a controller.

Whatever the method of solution employed, five different types of curves may finally be obtained. These are shown in Figure 20 and are called respectively, *stable and overdamped, stable and critically damped, stable and underdamped, conditionally stable or oscillatory,* and *unstable.*[12]

Most fluid flow and heat transfer processes such as occur in the petroleum and chemical industries give overdamped or critically damped curves when no controller is attached to the process. A physical example of the underdamped type of curve is best exemplified by the action of a spring which is subjected to a displacement and then released. When the spring friction is assumed to have a smaller and smaller value the degree of oscillation increases until for the case of the perfect spring, i.e., no internal friction, the conditionally stable or permanently oscillatory system is obtained. The unstable condition is not normally present in purely physical systems but can easily be present is those involving exothermic chemical reactions.

Whenever a feed back loop and an automatic controller are added to a physical system, that is, whenever a closed loop system is formed, the possibility of an oscillatory or unstable system is an ever present danger. It exists when the values of the control constants are too

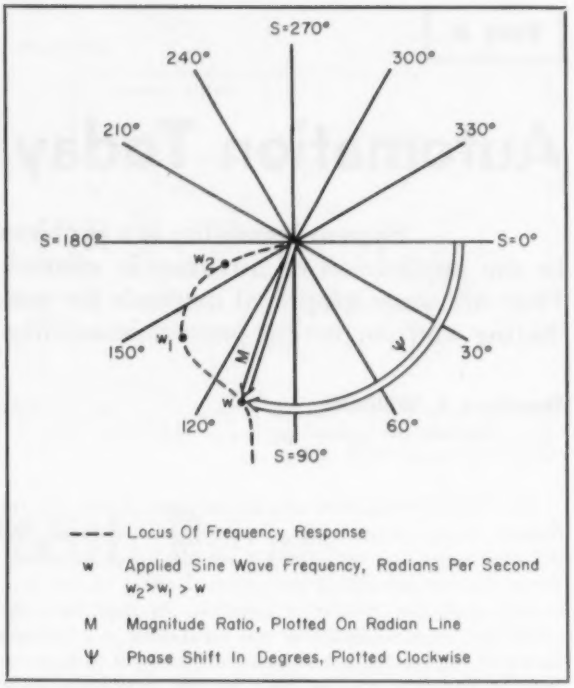

FIGURE 22—The frequency response of a system may be represented on a Nyquist diagram.

large. Too large a controller constant results in a correction whose effect is larger than that of the original disturbance. The effect of this larger correction is then amplified by subsequent corrections with the result that variations of the output variable quickly get out of hand.

For a linear system the size of the input step function has no bearing on the stability of the system. For nonlinear systems, however, the size of the step may be a very important factor in stability.

Frequency Response determines a process-controller system response and stability by applying a sine function disturbance rather than a step function to the input variable. The graph of magnitude versus time of the output variable is then compared to a similar graph of the disturbance applied to the input variable to determine: (a) the magnitude of the peaks of the output as compared to the input, and (b) the time differential between corresponding points on the two curves as compared to the time required for one complete cycle of the sine wave applied at the input. A *magnitude ratio* which is the ratio of the amplitude or size of the output wave compared to that of the input wave is thus determined. The value of this magnitude ratio may be greater or less than 1.0 depending upon the nature of the process and the control applied. The time variation between common points on the two waves is known as the *phase shift* and is expressed in degrees of arc where the time of the complete sine wave corresponds to 360 degrees of arc. A diagram of these concepts is given in Figure 21.

The magnitude ratio and the phase shift of the output variable are a very definite function of the frequency or repetition rate of the applied sine wave and thus they must be determined for a wide range of frequencies in

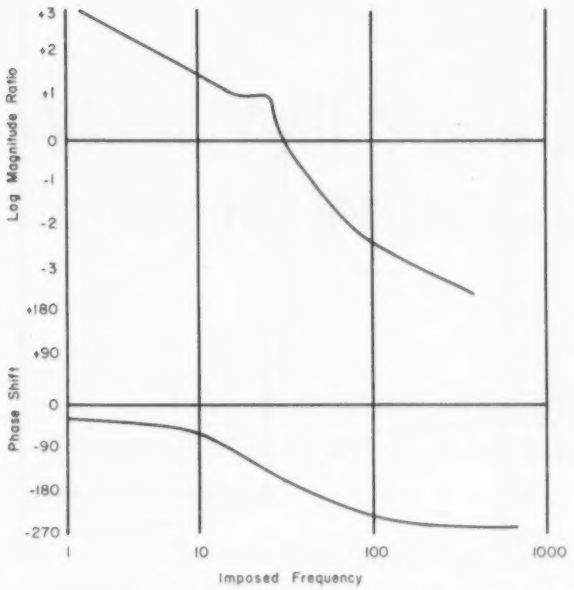

FIGURE 23—In the Bode diagram log of the magnitude ratio and the phase frequency measured in radians per second shown.

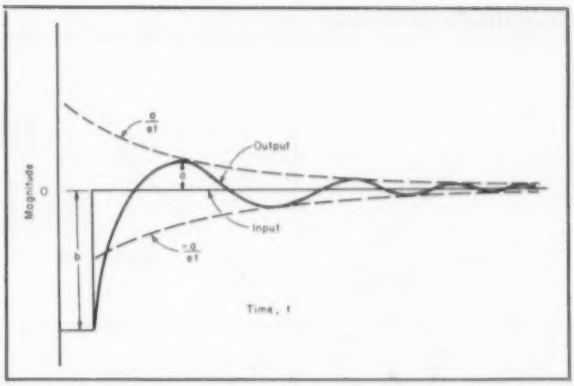

FIGURE 24—To assure stability, the output response should fall within the area defined by a/et and minus a/et.

order to be valuable. However, they need only be determined for the open-loop (no feed-back) case. The effect of an added controller upon frequency response may be determined by graphical methods. This is in contrast to the case of transient response just discussed where the equations must be resolved for each controller case to be investigated. Thus for transient response, the controller

WHY MEASURE TRANSIENT RESPONSE?

Transient response essentially gives one a qualitative rather than a quantitative answer. It does however give the only ultimate absolute answer as to the stability or instability of a system. Its use in a theoretical investigation by hand methods for all but the simplest systems is extremely difficult and is not encouraged. Where such things as non linearities require its use, an electronic computer is recommended.

- **Advantages**
  1. Transient response is carried out in closed loop system, thus any non-linear effects arising from the connection of the controller to the process such as are very prevalent with on-off types of control are automatically taken into account.
  2. The step function is the most severe type of disturbance to which the system could be subjected, thus stability to this disturbance assures stability in the face of all others. This point is particularly important in relation to non-linear systems where disturbance severity is an important factor in control stability.
  3. Transient response is the easiest type of disturbance to apply to the process since it usually requires no special equipment. The sudden opening or closing of a valve or a sudden change in the set point of a controller is sufficient to supply a step function disturbance to the process.
- **Disadvantages**
  1. Transient response to be valuable must be applied in a closed-loop system. Thus one must have a controller present to make the test. Therefore a wide range of tests is impossible without a great deal of control equipment.
  2. Since the step function is the most severe type of disturbance which can be applied the chances of doing damage to the system by the application of too large a disturbance or the use of an incorrect set of controller constants is always present.
  3. The theoretical application of transient response is the most difficult, again because a closed-loop system must be employed. The differential equation of the closed-loop system are invariably more involved and much more difficult to solve than the corresponding open-loop equations. This is mainly due to the appearance of terms in the numerators of the transfer functions, thus serving to greatly complicate the operational calculus solutions of the corresponding differential equations.

WHY MEASURE FREQUENCY RESPONSE?

Frequency response lends itself readily to a preliminary theoretical investigation of process control. While the method generally breaks down for a non-linear system, the partial answer obtained from the study of a postulated linear system resembling the action of the non-linear one may still be very valuable.

- **Advantages**
  1. The initial data collection required for an experimental determination of frequency response can usually be taken on the open-loop system thus no controller need be on hand. This is especially important when initially applying automatic control to a previously hand operated process since no investment for control equipment need be made prior to carrying out the stability analysis.
  2. Graphical methods have been very completely worked out and systematized for the application of various types of control by theoretical methods once the initial open-loop data has been obtained for the process. It is thus quite easy to determine whether a given controller is adequate to the task or conversally just what type of control is necessary, provided the response of the system to control action can be considered linear. In addition for linear systems the graphical methods can be used to determine even the open-loop response.
- **Disadvantages**
  1. A great deal of specialized equipment is necessary to obtain an experimental frequency response on a particular process since the equipment must be capable of applying a sinusoidal disturbance upon the feed composition, the feed rate, the process ambient pressure, the steam flow, etc. Also this sinusoidal response must cover a very wide range of frequencies to be truly valuable.
  2. Frequency response methods break down if the controller action-process response loop is non-linear.

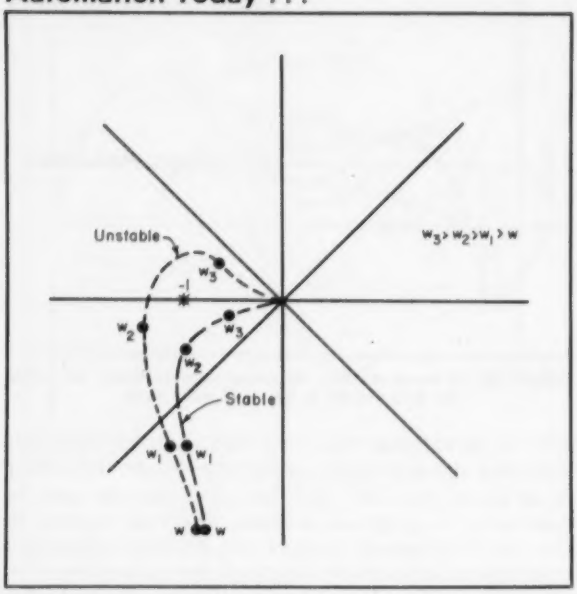

FIGURE 25—In the Nyquist diagram, a system is stable provided the curve of increasing frequency does not intersect the 180 degree phase line to the left of minus one.

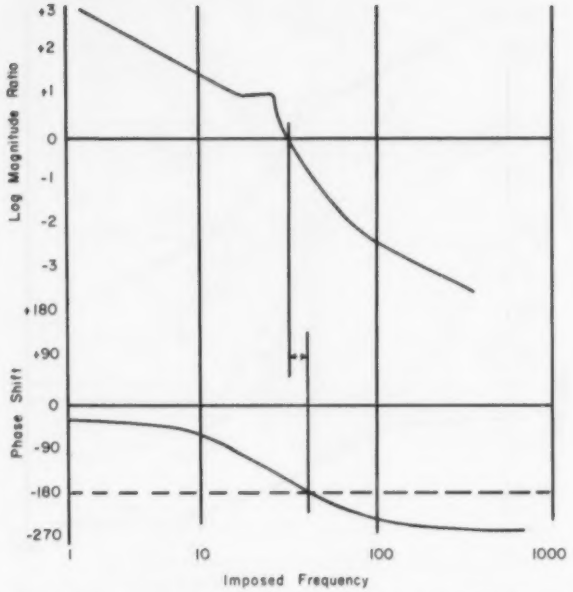

FIGURE 26—In the Bode plot, the intersection of the magnitude ratio curve with the zero axis must be at a lower frequency than that at which the phase shift plot intersects the 180 degree line in order for the system to be stable.

equations must be included in the general equations of the process prior to solution which greatly increases the complexity of the mathematics involved. As just mentioned, this added complexity is usually unnecessary in working with frequency response.

There are two common methods for using the open loop frequency response data to determine the proper controller to use on a process and to check the stability of the resulting process-controller complex. These are the Nyquist[8] and the Bode[3] methods.

The Nyquist method plots magnitude ratio on a radius scale and phase shift in degrees on a circular diagram, Figure 22.

The Bode method consists of two graphs. One plots the logarithm of the magnitude ratio on the ordinate versus the logarithm of the frequency on the abscissa. The other plots the phase shift in degrees versus the logarithm of the frequency. These are usually plotted on the same sheet of paper to facilitate comparison. Figure 23 shows this comparison.

Frequency response methods bear an additional advantage over transient response methods for theoretical work in that both the Nyquist and Bode plots may be approximated, (for linear systems), from the transfer function equations themselves. Thus the labor of solution of the differential equations is avoided.

Still another type of graphical method has recently been receiving wide attention. This method also uses the transfer function form of the differential equations of both the open loop format of the process to study theoretically the stability and response of the system. This is the Evans or root-locus method.[5] However since its use involves a considerable knowledge of the use and manipulation of electrical vectors and complex variables it will not be discussed here beyond this brief mention.

CRITERIA FOR STABILITY

Transient Response methods derive an actual plot of the action of the output variable of the process with time. Mere inspection of these results should determine directly whether the process plus controller is stable, oscillatory or unstable. However, experience has shown that the best controller action is obtained if the following additional rules are also obeyed:[14]

1. Critical damping, while the most desirable, is very hard to obtain; therefore, to avoid the sluggish action of overdamping, choose the controller constants so that a slightly underdamped system is obtained.
2. Regulate this underdamping so that the initial overshoot is less than 20 percent of the magnitude of the difference between the initial and final control points.
3. Further regulate the system so that the magnitude of successive oscillations are less than

$$\frac{1}{e} = \frac{1}{2.718} \cong \frac{1}{3}$$

of the immediately preceding one.

These points are illustrated in Figure 24. The proper choice of a controller to effect this response must be done by trial and error means remembering that derivative and proportional response tend to speed up the process and thus reduce the damping on a system while integral control makes a system more sluggish, i.e., increases the damping.

Frequency response criteria are applied to the diagrams of Figures 25 and 26 to determine whether or not the system plus controller will be stable.

End of Part 4. Part 5 will appear in an early issue of PETROLEUM REFINER

When Will Shale Oil Compete With Crude?

With advanced methods, shale production cost is claimed to be as low as crude oil being recovered in many U. S. fields.

Volume throughput and continuous retorting operation are the big factors in bringing down the cost.

OIL FROM SHALE soon may become competitive with crude oil. Engineers say that soon it will be possible to produce shale oil, or "kerogen," at the same cost that crude oil is being produced from many U. S. fields.

A competitive cost for the shale oil would be based on volume throughput and a continuous retorting operation. Methods involved have been developed by the U. S. Bureau of Mines.

Billions of barrels of oil are locked in Colorado's vast reserves of oil shales. The U. S. government has given the bureau the job of finding a way to produce this oil economically, and the bureau has been devoting continuous efforts to the assignment. The oil industry naturally has kept a close check on these efforts.

For the past few years the bureau has concentrated its work in the Rifle area of Colorado. A corps of experts has made considerable progress in developing methods of mining the shale and extracting the oil from it. As a result, the gap between a profitable and a non-profitable method of producing shale oil rapidly is being bridged.

The most significant recent development in the shale project of the Bureau of Mines, under the Synthetic Liquid Fuels Program, is the success achieved in extraction of kerogen or shale oil under a continuous process. Previous experiments, which first started in 1945, had been conducted in batch-type retorts. Data from the batch process were used to design the first continuous gravity-feed retort used at Rifle.

A bed of shale moving downward through the retort, between two parallel sets of louvers, was retorted by a stream of hot retort gas, flowing horizontally through the bed, entering at one set of louvers and leaving through the other. This was called the Gas-Flow process.

A cost-evaluation study showed that investment costs would be high for this process and that cost of producing liquid fuels from oil shale is influenced to a rather large degree by the magnitude of investment cost. Furthermore, heat economy of the Gas-Flow process is poor. Accordingly, efforts on retorting were diverted to development of a low-investment-cost, thermally efficient process.

From experience gained, a retort was designed as a multi-purpose unit, capable of several operating arrangements. Continued operations and modifications of the new unit finally led to the development of the Gas-Combustion process and operation of a 6-ton-a-day pilot plant. Over 300 pilot-plant tests were made during the investigation of this process.

In all these experiments shale was heated with hot combustion gases generated in the retort vessel. The same basic vessel was used for all but a few of the experimental runs. It was a vertical, refractory-lined, cylindrical retort, 12 feet high and 20 inches inside diameter. For flexibility it was divided into three flanged sections which could be interchanged or used for various modifications of the retort.

In all the modifications, the retorted shale was removed at the bottom of the retort by a turntable, which could be operated at varying speeds, to control the rate of shale flow through the retort. Chains attached to the bottom of the turntable carried the spent shale to an opening above a sealed container. Principal dimensions of the Gas-Combustion retort are shown in Figure 1.

In this process, part of the heat for retorting of the shale is generated by burning recycled product gas in a combustion zone within the descending shale bed in the retort. Additional heat is supplied by combustion of the carbonaceous residue remaining in the spent shale after the oil has been distilled. Air for combustion is admitted through an air distributor in the center of the bed at about the midpoint of the retort. Hot gas rising from the combustion zone heats countercurrently the descending raw shale and liberated shale oil by pyrolysis of the shale.

After passing through and exchanging heat with the incoming raw shale, oil is condensed as a fog or mist in the gas, which is withdrawn at the top of the retort. The cool gas is then piped to an oil-recovery system where the oil is separated from the gas in centrifugal separators or other types of mechanical or electrostatic separators. The hot, spent shale below the combustion zone is cooled by heat exchange with recycle gas, which is a portion of the effluent gas from the oil-recovery system.

Important desirable features of the process are:

1. The spent shale leaves the retort at a low temperature of less than 200° F.; heat is conserved, and handling and disposal of the spent shale is simplified.

2. Temperature of the exit gas and

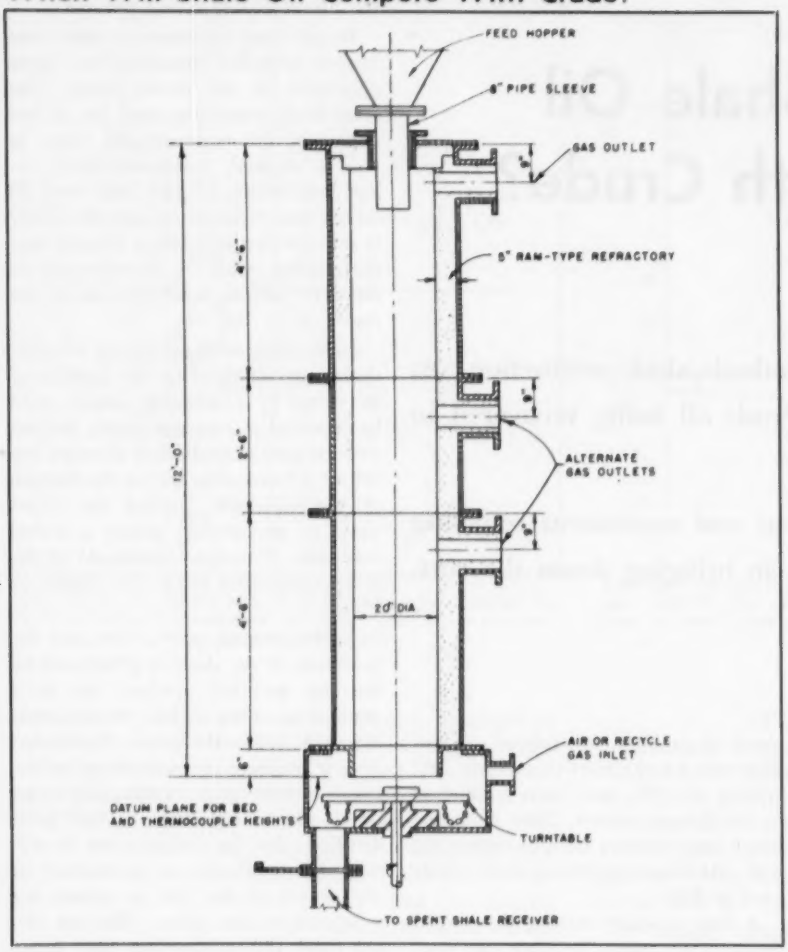

FIGURE 1—Basic oil shale retort.

entrained oil is not over 175° F. At this temperature the oil is in the form of a mist that can be separated almost completely by mechanical means without further cooling.

3. Owing to the high over-all efficiency of the retort, energy in excess of that required for the process is available. This excess energy, in the form of low heating value gas, is suitable for steam or power generation or other purposes.

4. No cooling water is needed either at the retort or in the oil-recovery system. This is a highly important point since most of the richer beds of shale in the U. S. lie in semi-arid or desert regions where water is scarce.

5. Yield of oil from the Gas-Combustion retort, under properly controlled conditions, is high, approximately 95 percent of the Fischer assay of the shale.

Operating problems of the process are:

1. Temperature of the combustion zone must be controlled within fairly narrow limits. If the temperature is too low, the fire may go out; if too high, the mineral constituents of the shale fuse, forming clinkers.

2. Refluxing usually occurs unless conditions are controlled properly. This results in excessive cracking of the oil and a consequent lower oil yield. It also may result in agglomeration of shale particles owing to the formation of pitch or coke in or somewhat above the retorting zone.

3. For the best operation, the combustion zone must be uniform across the retort. An uneven combustion zone invariably causes erratic operation and low oil yields. Such a condition may result from clinker formation or from refluxing.

4. Rich shales containing more than about 33 gallons of oil per ton tend to agglomerate and form coke in the retorting zone, which interferes with uniformity of shale and gas flows.

Most of the troubles listed can be surmounted by careful control of the shale-air ratio and the shale-recycle gas ratio. These ratios must be determined through experience for shales of different compositions. With average Colorado shale as mined, containing about 30 gallons of oil per ton, the pilot plant has been run continuously for weeks with only minor operating difficulties.

Preliminary tests indicate that addition of a small amount of sodium chloride to the raw shale causes the formation of a more stable oil mist in the retort gas, owing to nucleation effects of the sublimed salt. When salt is added, operating conditions may be varied more widely without loss of oil by refluxing and cracking in the shale bed.

Many tests have been run without brine in which high oil yields were obtained. Data show that in most of these tests there was little or no refluxing and cracking of oil. From this it appears that addition of brine to the shale allows the retort to be operated under more varied conditions of shale, air, and recycle rates.

Without brine these flows must be held within narrow limits to prevent refluxing. Refluxing is undesirable not only because it reduces oil yield but also because it causes the shale to become coated with oil, resulting in the formation of agglomerated masses by the coking of the pitch remaining on the shale after redistillation of lighter portions of the oil.

Work is continuing on the process to improve yields, simplify operation, increase the throughput of shale, and to learn more about the chemical and physical phenomena encountered in the pyrolysis of oil shale by this process.

ACKNOWLEDGMENT

The above is excerpted from Bureau of Mines Report of Investigation 5154 by A. Matzick, J. R. Ruark and M. W. Putnam. The complete report can be obtained by writing U. S. Bureau of Mines, Pittsburgh, Penn.

One company has spent $1.5 million on shale oil research . . . See Page 161

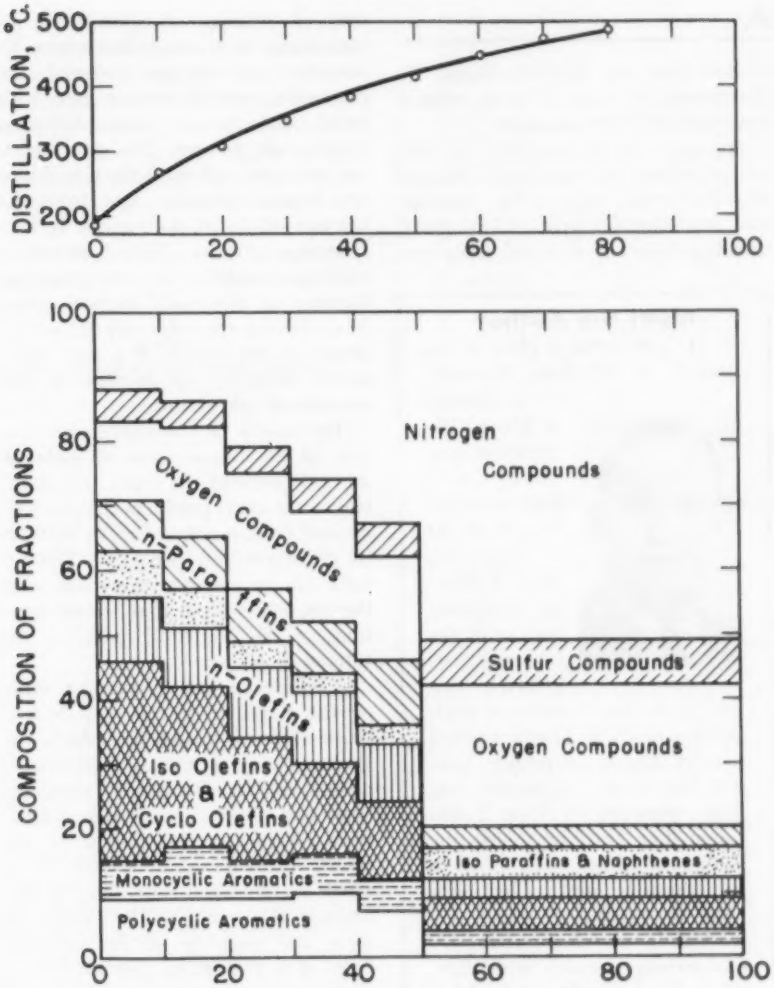

FIGURE 1—Shale—oil distillation fraction, weight %.

Retort Oil Shale For Chemicals

The chemicals in oil shale, recovered as by-products, can make this material an economical source for liquid fuels.

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WHEN THE tremendous reserves of oil shale in the U. S. begin to be utilized commercially, a large additional source of chemicals will become available. The by-products from the manufacture of fuels will be essentially the same as those obtained from petroleum operations, but often greater quantities are contained in shale oil than in petroleum. Oil shale also may be processed primarily for the manufacture of chemicals.

The economics of some of the foreign oil-shale operations have been benefited greatly by the recovery of by-products, including chemicals, from processing to produce fuels. Paraffin wax always has been a high-value product of Scottish operations[7] and ammonium sulfate was their "bread and butter" product for years. More recently, detergents are being manufactured from C_{10} to C_{20} olefins. The Swedish industry[7] also has depended upon the production of ammonium sulfate, sulfur, lime and liquefied petroleum gases to maintain a profitable level of operations. Paraffin wax and lubricants, although products secondary in volume, are of prime importance in Spain.[14] The oil-shale plants in South Africa[18] and Estonia produce asphalts as secondary products and recover tar acids for use as flotation oils in South Africa and wood-preserving oils in Estonia.

As the amount and type of chemical products that may be recovered from oil-shale operations depend to a large extent upon the compositions of the oil shale, shale oil and their products of processing, a brief discussion of what we know of their characteristics and composition is given to indicate the products we may expect.

Composition of Shale Oils From Low Temperature Retorting—The oil produced by retorting oil shale resembles petroleum in that it is composed of hydrocarbons plus sulfur, nitrogen, and oxygen derivatives of hydrocarbons. However, it differs from petroleum by containing larger quantities of nonhydrocarbons, particularly nitrogen and oxygen compounds, which, in the high-boiling fractions, may be the major constituents. Also, the hydrocarbons of shale oil are highly unsaturated, resembling the products of thermal cracking of petroleum, as would be expected because of the pyrolytic origin of shale oil. Shale oil, in some respects, may be considered as intermediate in composition between petroleum and coal tar. The range of values for the carbon/hydrogen ratio is 7-9 for shale oil as compared to 6-7 for petroleum and 10-16 for coal carbonization products.

The method used to retort oil shale affects, to a considerable extent, the properties of oils produced from a given shale[5] as is shown in Table 1.

Although there are some variations in properties, the first six oils are very similar. These oils were produced in conventional retorts in which the oil was formed and removed from the retort as soon as the shale reached its minimum retorting temperature of about 900 F. The last two oils in Table I were produced by a process designed to heat the shale rapidly to a temperature considerably above that attained in conventional retorts. They show marked differences from the others. The aromatic content increases with the pyrolysis temperature, as does the nitrogen content but the sulfur content remains fairly constant. The effect of high-temperature retorting will be discussed more fully later.

Oils produced from Colorado oil shale by conventional retorts are fairly similar, and an N-T-U oil may be regarded as typical.[13] This oil is deficient in low-boiling constituents, with the gasoline-boiling-range material amounting to only 2.7 percent. Also only 52.8 percent of the oil can be distilled below 572 F. at an absolute pressure of 40 mm. Hg.

Hydrocarbon Constituents—One of the most comprehensive examinations of a single shale oil has been reported by Cady and Seelig.[4] They characterized an entire crude shale oil produced in the N-T-U retort from Colorado oil shale. Their results are depicted in Figure 1. The crude shale oil was distilled under high vacuum into five fractions, each containing 10 percent of the shale oil, and a residue comprising the remaining 50 percent. A unique and comprehensive system of analysis of these fractions in summary showed the shale oil to contain 61 percent nonhydrocarbons. Of this quantity, 30 percent of the molecules contained 1 atom of nitrogen, sulfur, or oxygen, and 70 percent contained two or more hetero-atoms. They concluded that the highest boiling 30 percent of the shale oil must contain essentially no hydrocarbons.

Infrared examination of the straight-chain hydrocarbons indicated that the olefins were of the terminal and trans-internal types. Conjugated diolefins were not detected. Examination of patterns of substitution of monocyclic aromatic hydrocarbons by infrared spectroscopy showed the para-substituted to predominate, with small amounts of meta-substituted compounds present. No substitution on the alpha carbon of the side chains was found, indicating that aromatics are not alkylated during the N-T-U retorting process. With increasing molecular weight, the corresponding increase in side-chain carbon atoms is accounted for primarily by an increase in the length of a side chain rather than by an increase in the number of side chains.

The results of the above examination of the composition of shale oil are indicative of the types and quantity of chemical products that may be derived from it either directly or from its decomposition products. The results are in general agreement with the more detailed analyses of fractions of the crude oil made by the Bureau of Mines.

A comprehensive composition study of the naphtha fraction of N-T-U crude shale oil has been made by the Bureau, using precision fractionation, adsorption, spectrometric examinations and physical properties of fractions. A recent compilation of the results of this work,[3] expressed in terms of estimated individual hydrocarbons, is summarized in Table 2 to show the quantity of the different types of hydrocarbons present.

TABLE 2
Composition of Hydrocarbons in N-T-U Shale-Oil Naphtha

Hydrocarbon Type	Volume Percent of Naphtha
Normal Paraffins	17.1
Branched Paraffins	10.3
Cycloparaffins	7.8
Aliphatic Olefins	35.3
Cycloolefins	15.4
Aromatics	14.1
	100.0

As the content of straight-run naphtha in N-T-U shale oil is only 2.7 percent, the hydrocarbon portion probably would be of little interest for the extraction of chemicals. However, thermal cracking of the crude oil will yield up to 50 percent of naphtha having a similar composition. Cracking conditions[10] have been shown to affect the composition to some extent, yielding naphthas having olefin contents ranging from 42 to 55 percent, aromatics from 10 to 17 percent and paraffins and naphthenes from 32 to 42 percent. The nonhydrocarbon por-

TABLE 1
Properties of Oils Produced From Colorado Oil Shale by Various Retorting Methods

Retorting Method	Gravity, A.P.I.	Sulfur, Weight Percent	Nitrogen, Weight Percent	Analysis of Distillate Boiling to 600 F.		
				Saturates, Volume Percent	Olefins, Volume Percent	Aromatics, Volume Percent
N-T-U	19.8	0.74	1.78	36	36	28
Pumpherston	25.7	0.77	1.57	30	38	32
Gas Flow	16.0	0.61	2.10	27	43	30
Royster	19.7	0.67	1.97	27	41	32
Parry	20.5	0.87	1.81	26	46	28
Gas Combustion	18.6	0.69	2.13	27	44	29
1,200 F. High Temperature	16.5	0.82	2.46	10	36	54
1,500 F. High Temperature	1.6	0.76	3.08	1	1	98

Meet the Author

H. M. THORNE is chief of the Branch of Oil-Shale Research at the Bureau of Mines' Petroleum and Shale - Oil Experiment Station at Laramie, Wyo. Following is graduation from the University of Oklahoma with a degree in chemical engineering in 1924, Thorne worked a short time at the refinery Cosden Petroleum Corporation was then operating at West Tulsa. Later that year, he joined the Bureau of Mines at its office in Bartlesville, and he has been with the bureau ever since. He worked in petroleum-chemistry and refining research until 1926, when he was sent to Boulder, Colo., to start research in shale-oil refining. He had been there four years when he was transferred to Laramie in 1930 to take up petroleum research. Fourteen years later he was named chief of the Oil-Shale Research branch at Laramie. In 1946, he was the chemical-engineering industrial staff member of the U. S. Reparations Mission to Korea and Manchuria.

tion of the naphtha probably would be of greatest interest in chemicals manufacture although some of the olefins may be of interest as charge stocks for chemicals production.

The olefins in the higher-boiling fractions, such as the gas oil shown in Table 3 and the paraffin wax distillate[16] in Table 4, may prove to be of value as chemical intermediates in the manufacture of such products as detergents.

TABLE 3
Types of Compounds in Gas Oil From Colorado Shale Oil

	Weight Percent
Nitrogen Compounds	43
Saturates	16
Olefins	19
1—Ring Aromatics	9
2—Ring Aromatics	7
3—Ring Aromatics	6

TABLE 4
Composition of Wax Distillate and Waxes From Colorado Shale Oil

	VOLUME PERCENT		
	Wax Distillate	Crude Wax	Fully Refined Wax
Nitrogen Compounds	43	0	0
Paraffins and Naphthenes	20	83	100
Olefins	16	17	0
Aromatics	21	0	0

Nonhydrocarbon Constituents—The components of straight-run or cracked naphthas that probably will have greatest chemical interest are the tar acids made up primarily of phenol and its homologues. All of the phenols[21] up to and including the dimethyl and ethyl compounds have been found as well as 2, 4, 6-trimethylphenol, two dihydroxy compounds, and a methyl derivative of the latter. Other oxygen-containing compounds that have been identified in shale oils include carboxylic acids, ketones, ethyl alcohol, isopropyl ether and benzofuran.

Tar Acids—Tar acids extracted from cracked shale-oil gasoline were purified[17] to yield a product similar to that produced commercially from coal tar. The starting material was a caustic sludge from refining thermally cracked naphtha at the Oil-Shale Experiment Station, Rifle, Colo. The naphtha, equivalent to about 50 percent of the crude, was produced by recycle cracking of N-T-U crude oil. A crude tar-acid fraction was sprung from the sludge by acidifying to a pH of 7 to 8 with dilute sulfuric acid, thus partly separating the tar acids from the carboxylic acids. These crude

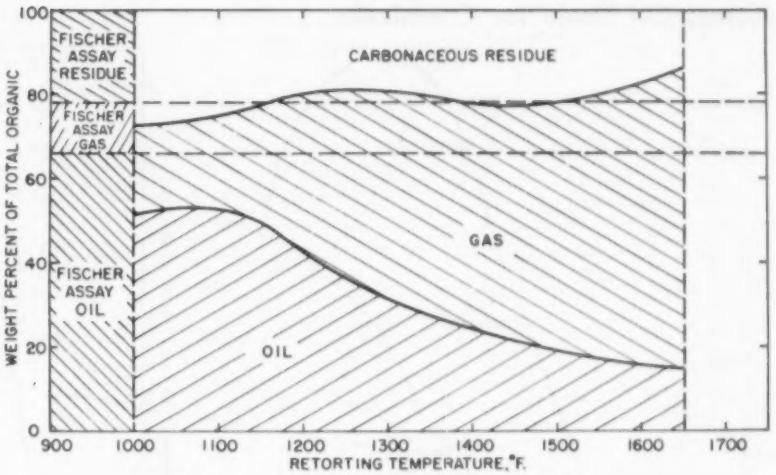

FIGURE 2—Distribution of organic matter in retorting products.

tar acids had a foul odor, were reddish-brown to black and contained impurities consisting mainly of nitrogen bases, hydrogen sulfide, organic sulfur compounds, neutral oils, additional carboxylic acids, water and nondistillable material. They contained 2.28 percent sulfur, 2.43 percent nitrogen, 6.1 percent water, 13.3 percent nondistillable material and 10.7 percent low-boiling tar bases and neutral oils.

A purification procedure consisting of the following major steps was applied in the laboratory to seven liters of these tar acids:

1. Vacuum distillation to remove water and high-boiling residue.
2. Air blowing to remove hydrogen sulfide.
3. Preparing sodium salts of phenols by adding sodium hydroxide.
4. Steam stripping to remove additional non-phenolic contaminants.
5. Acidification with carbon dioxide to pH 10 to liberate phenols.
6. Vacuum distillation to remove remaining contaminants, producing a stable product.

The sulfur and nitrogen contents of the purified phenols were 0.01 and 0.015 percent, respectively. The major portion of the product upon distillation was virtually water white but changed to a light yellow after being exposed to light for 48 hours. The color of the combined distillate when exposed to light for several months became a clear amber. Color-stable, water-white phenols were produced if 2 percent of concentrated sulfuric acid was added to the phenols before final distillation. The recovery of purified phenols was equivalent to approximately 1.3 pounds per barrel of cracked gasoline. These refined phenols readily formed light-color phenolic resins when condensed with formaldehyde in the presence of an acid catalyst.

A portion of this refined phenol product was fractionated into 22 4 percent fractions, two 2 percent fractions and a residue. The first 88 percent was distilled at 100 mm. Hg. absolute pressure and the remainder at 10 mm. with a reflux ratio of 100 to 1. The fractions were analyzed by infrared spectroscopy in accordance with the method of Friedel and Pierce.[6] Twelve different phenols were identified. These were phenol, the three monomethylphenols, 2-ethylphenol, 3-ethylphenol, and all six dimethylphenols. Table 5 shows the quantity of each phenol recovered.

TABLE 5
Refined Phenols From Thermally-Cracked Shale-Oil Naphtha

COMPOUND	Weight Percent
Phenol	7.57
2-Methylphenol	15.03
3-Methylphenol	9.23
4-Methylphenol	10.67
2-Ethylphenol	0.99
3-Ethylphenol	0.96
2,3-Dimethylphenol	8.44
2,4-Dimethylphenol	17.27
2,5-Dimethylphenol	4.98
2,6-Dimethylphenol	2.90
3,4-Dimethylphenol	1.50
3,5-Dimethylphenol	15.89
Unidentified	4.66
Total	100.00

The final phase of the composition studies of N-T-U naphtha[19] included

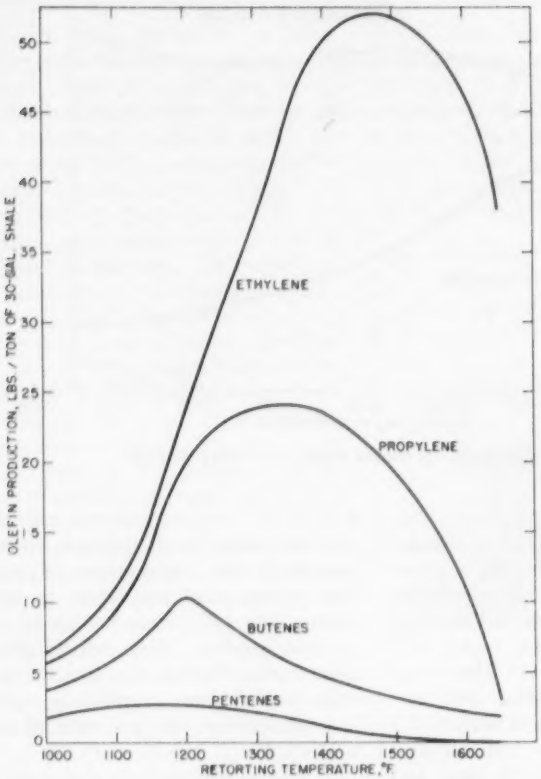

FIGURE 3—Yields of olefins in gases from entrained solids retort.

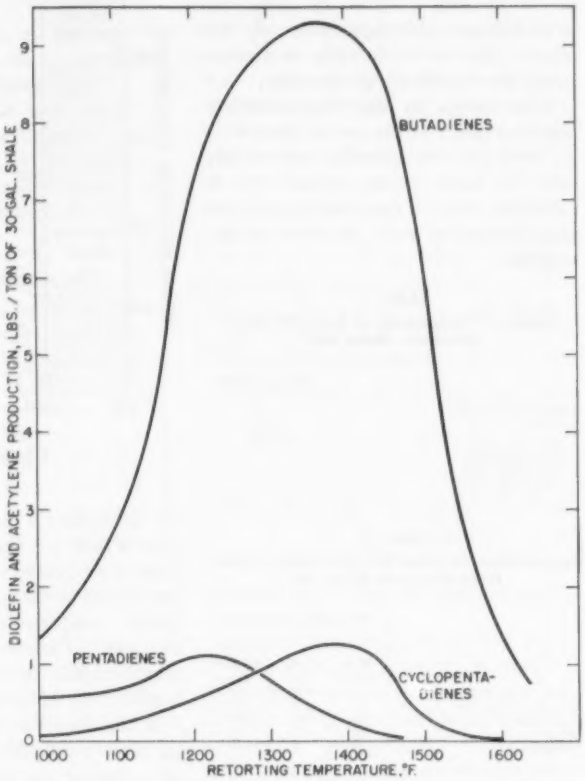

FIGURE 4—Yields of diolefins in gases from solids retort.

separation and identification of carboxylic acids and nonthiophenic sulfur compounds. Benzoic and n-heptanoic acids were identified. Cyclic sulfides having 5- and 6-membered rings contained most of the nonthiophenic sulfur in the naphtha accounting for about 20 percent of the total sulfur. Kinney et al.[9] identified 17 thiophenes from Colorado shale oil which represent about two-thirds of the thiophenic sulfur in the naphtha. The thiophenes contain almost 80 percent of the sulfur in the shale-oil naphtha. The organic sulfur compounds contained in shale oil do not appear to be of any great interest to the chemical industry at present.

Tar Bases—Basic nitrogen compounds, primarily pyridine and its homologues, enjoy a limited chemical, pharmaceutical, and industrial market; and it has been shown that, after stabilization, they may be added to gasoline to increase its octane number.[2,18] The tar bases in the naphtha boiling range after the removal of gum-forming materials have average blending values in several types of gasoline of 100 octane number by the motor method and 117 octane number by the research method.

A review of the work of isolating nitrogen compounds from shale oil by Van Meter et al.[21] showed that 2, 4, 6-trimethyl pyridine is the predominant compound. 5, 6-dihydropyridine, quinoline, and 2-methylquinoline have been identified in addition to the alkylpyridines. Pyrroles have been identified in Colorado shale-oil naphtha by Janssen[8] who isolated pyrrole and 2-methylpyrrole. 2, 3, 4, 5-tetramethylpyrrole and 2, 4, 5-trimethyl-3-ethylpyrrole, which are basic compounds, and benzonitrile, 2-methylbenzonitrile and 3-methylbenzonitrile were isolated by Van Meter.

Tar bases were extracted and purified[17] from the dilute acid sludge from refining the gasoline made by recycle cracking of N-T-U heavy gas oil. The impurities present in the tar bases, consisting essentially of neutral oils and tar acids, were removed by steam stripping. The bases then were regenerated with 40 percent sodium hydroxide solution, their pH adjusted to 12, water-washed, dehydrated, and blown with dry air at 350 F. for 12 hours under total reflux. A black, finely divided residue formed by this treatment was removed by filtration. The filtered bases were distilled at 80 mm. Hg absolute pressure. Their initial boiling point was 167 F. and their end point 284 F.

This refined product was completely soluble in 10 percent hydrochloric acid, had a relatively stable light-straw color, a sulfur content of less than 0.03 percent, and consisted only of basic nitrogen compounds possessing the characteristic odor of the pyridines. The volume of purified tar bases that may be recovered from cracked shale-oil naphtha usually is several times that of purified tar acids. In addition to their high octane blending value, the tar bases have other potential uses, for example, rust inhibitors, pharmaceuticals, and the base stock for many nitrogen-bearing chemicals.

Nitrogen compounds have been found to inhibit the activity of petroleum cracking catalysts, and both

the sulfur and the unstabilized nitrogen compounds as they exist in shale oil are considered detrimental to finished gasoline and other fuels. Chemical treatment or extraction of the oxygen, sulfur and nitrogen constituents usually will make them available as by-products. However, their removal by hydrogenation, a favored method, will convert these nonhydrocarbon elements into water, hydrogen sulfide and ammonia. The hydrogen sulfide may be converted to elemental sulfur or sulfuric acid. These products and ammonia are expected to be valuable by-products of shale-oil processing.

Composition of Shale Oils From High Temperature Retorting—The foregoing discussion of the composition of crude shale oil and its products pertained to conventional or low-temperature retorted oils. However, it was recognized early in the program that the characteristics of conventionally retorted shale oil were poorly suited to the production of high-octane gasoline or chemical products, so retorting experiments were made at other than conventional conditions[1] in an attempt to improve the quality of the products. These experiments showed that subjecting the shale to more severe retorting temperatures resulted in an increase in the proportion of low-boiling material in the product and an increase in the percentage of aromatic constituents.

The yield of products from the organic material in the shale by conventional retorting is similar to that of the Fischer assay[12] retorting procedure (approximately 65 percent oil, 25 percent carbonaceous residue and 10 percent gas). At higher retorting temperatures the yield of oil decreases and that of gas increases as shown in Figure 2.

The more promising conventional-type retorts under development utilize internal combustion; consequently, the retort gases are diluted with combustion products and are of little interest for chemicals manufacture. The diluted gases are burned to supply the needed process heat and power. On the other hand, the gases from high-temperature retorting, as evidenced by the results of retorting small-particle-size shale in an entrained-solids system,[11] increase in both volume and olefin content with increasing temperature as shown in Figure 3. Diolefins, principally butadienes, also are produced in increasing amounts at higher temperatures, as shown in Figure 4, and their yield, like that of the olefins, passes through a maximum in the range of 1200 to 1500 F. Table 6 gives the yields of all gases over the retorting temperature range of 1,000 to 1,650 F.

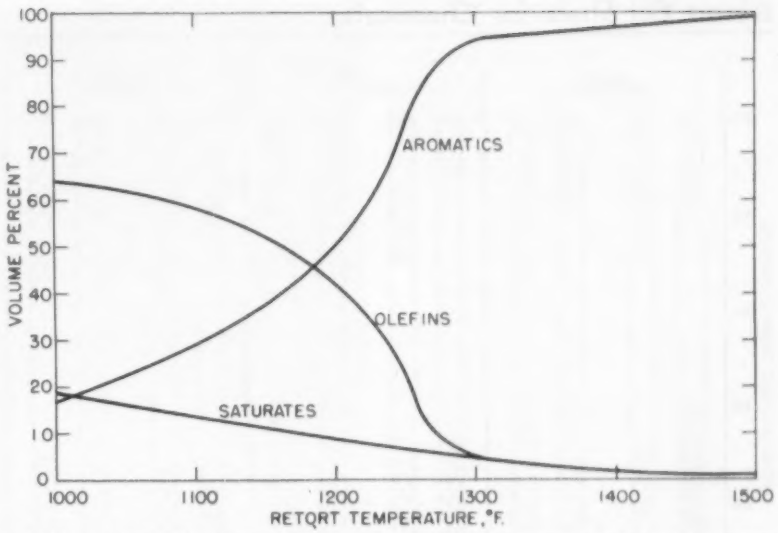

FIGURE 5—Hydrocarbon type distribution in naphthas from entrained-solids retort crudes.

TABLE 6—Yields of Gases From Retorting 1 Ton of 30-Gallon-Per-Ton Shale
(Standard Cubic Feet)

	RETORT TEMPERATURE, F.							
	1000	1100	1200	1300	1400	1450	1500	1650
Methane	131	189	339	607	797	997	1030	1273
Ethane	43	58	77	84	95	89	68	37
Propane	18	15	19	11	14	....	12	....
Butanes	8	7	2	1	....	15	....	....
Pentanes	2	10	2	1	....	8	....	....
Ethylene	87	146	319	500	675	701	701	512
Propylene	52	82	179	215	210	188	174	25
Butenes	26	40	70	48	36	....	6	13
Pentenes	10	14	10	3	6	8	1	....
Hexenes	....	1	1	....	....	8	....	....
Butadienes	9	19	50	63	65	45	3	13
Pentadienes	4	4	6	4	1	....	....	....
Cyclopentadiene	1	1	4	5	7	....	1	....
Acetylene	....	....	....	....	....	30	67	....
Benzene	....	....	....	....	1	30	....	26
Hydrogen	153	350	499	910	1020	1990	1550	4920
Carbon Dioxide	337	465	638	560	1500	2780	2080	3990
Carbon Monoxide	77	56	151	168	347	491	423	1670
Hydrogen Sulfide	19	23	21	14	10	8	12	25

TABLE 7
Yields of Low Molecular Weight Aromatics From 1 Ton of 30-Gallon-Per-Ton Shale

	Retorting Temperature, F.	
	1450	1650
	Yield, Pounds Per Ton	Yield, Pounds Per Ton
Benzene	13.27	19.95
Toluene	5.17	.99
Thiophenes	.33	.26
Xylenes and Ethylbenzene	....	.16
Styrene	1.57	....
Indene	1.54	....
Hydrindene	.19	....
Naphthalene	3.33	5.82
2-Methylnaphthalene	.48	....

Figure 5 shows the change in content of aromatics, olefins and saturates in naphthas produced at different retorting temperatures. These results show that the types of oil produced at different operating conditions vary from that approaching the quality of oil produced by conventional retorting to an oil composed entirely of aromatic compounds. A retorting temperature near 1200 F. will produce a high-octane motor gasoline, while temperatures above 1300 F. appear best for producing aromatic chemicals. Table 7 gives the yields of individual aromatic hydrocarbons at retorting temperatures of 1450 and 1650 F. It is noticeable that

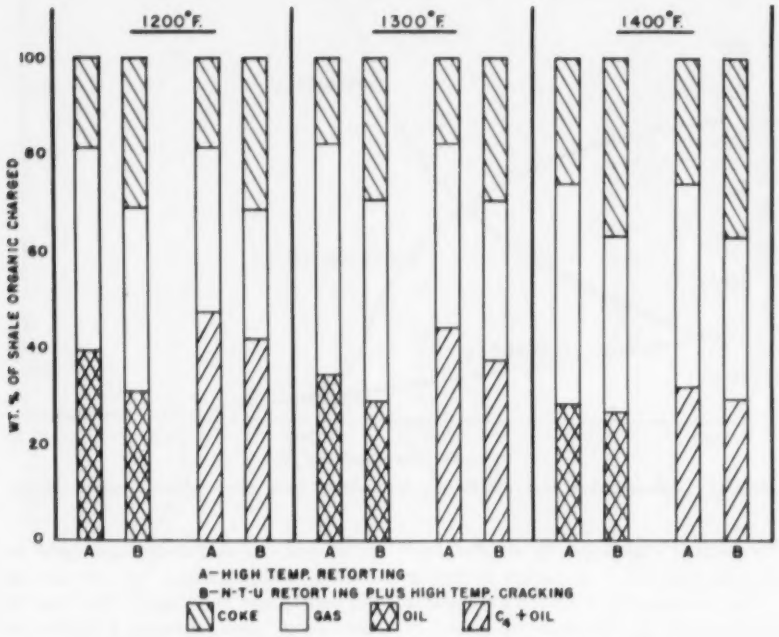

FIGURE 6—Distribution of organic matter among products of retorting.

the yields of substituted aromatics, such as toluene, are much greater at the lower temperature, while those of benzene and naphthalene were greater at the higher temperature, indicating greater shearing of side chains by this high-temperature pyrolysis.

The sulfur content of the naphthas from high-temperature retorted oils remained fairly constant at 0.7 to 0.8 percent, but the nitrogen content increased as the retorting temperature was raised, ranging from 0.57 percent at 1,000 F. to 1.24 percent at 1,500 F. Table 8 shows the tremendous effect of retorting temperature on the composition of the phenols[21] that may be extracted from the low-boiling fractions. Again, the greater effect of high-temperature pyrolysis on shearing of side chains is evident.

Products quite similar to those produced by high-temperature retorting can be obtained by vapor-phase cracking, at the same temperatures, of the oil produced in conventional retorts.[20] Yields based on the original quantity of oil shale also are in the same order of magnitude. Figure 6 shows the distribution of the original organic matter contained in the shale among the various products as obtained by retorting 30-gallon-per-ton oil shale at 1200, 1300 and 1400 F. compared with that obtained in cracking N-T-U shale oil at the same temperatures.

Summary

The establishment of an oil-shale industry in the U. S. will provide a large additional source of chemical products and intermediates, either as by-products from fuels manufacture or as products from operations primarily for chemicals.

It has been shown that operating conditions during the retorting and subsequent refining operations will affect the type and quantity of chemical products that will be available. Conventional low-temperature retorting probably will not provide gases of interest for manufacture of chemicals, and their heavy, high-boiling, crude oils will yield few chemical products, except by thermal cracking or other subsequent refining operations. Thermal cracking will enhance the yield of low-boiling tar acids (phenols), tar bases (pyridine homologues), non-basic nitrogen compounds, olefins and aromatics. Hydrogenation of crude oils or fractions will largely destroy the organic oxygen, nitrogen and sulfur compounds but will produce ammonia and hydrogen sulfide as by-products.

By controlling the operating temperatures during retorting of the oil shale or vapor-phase cracking of shale oil, great changes in the composition of the products can be attained. Higher retorting temperatures yield larger quantities of olefins in the gases and aromatics in the oils to about 1500 F., when the liquid product is made up entirely of aromatic hydrocarbons plus oxygen, sulfur, and nitrogen compounds.

TABLE 8
Phenols From Shale Oils Retorted at 1200 and 1500 F.

COMPOUNDS	Volume Percent of Crude Phenols*	
	1200 F.	1500 F.
Phenol	1.0	35.5
2-Methylphenol	3.4	21.9
3-Methylphenol	2.5	19.0
2-Ethylphenol	0.5	1.4
2,3-Dimethylphenol	3.1	2.9
2,4-Dimethylphenol	14.8	11.4
2,5-Dimethylphenol	...	2.9
3,4-Dimethylphenol	2.1	...
3,5-Dimethylphenol	4.3	...
Unidentified	14.1	...
Residue	54.2	5.0
	100.0	100.0

* Phenols extracted from distillates, each having a boiling range of 302 to 536 F.

ACKNOWLEDGMENT

The results reported here were obtained as part of the Synthetic Liquid Fuels Program of the Bureau of Mines at the Petroleum and Oil-Shale Experiment Station, Laramie, Wyo. Special acknowledgment is due W. I. R. Murphy, John S. Ball and their staffs for the results from their processing and composition research studies used in this report. The work was done under a cooperative agreement between the University of Wyoming and the U. S. Department of the Interior, Bureau of Mines.

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This recent photograph shows work underway on Union of California's shale oil plant. This is where demonstration retort and auxiliary equipment will be located. Underground piping is being put in place here. Plant site is 11 miles northeast of Grand Valley, Colo.

Union Oil Company of California Bets Heavily on Shale Oil

Shale oil is destined to occupy an increasingly larger share in the oil industry's thinking—and expenditures—if recent developments of Union Oil Company of California are any measure.

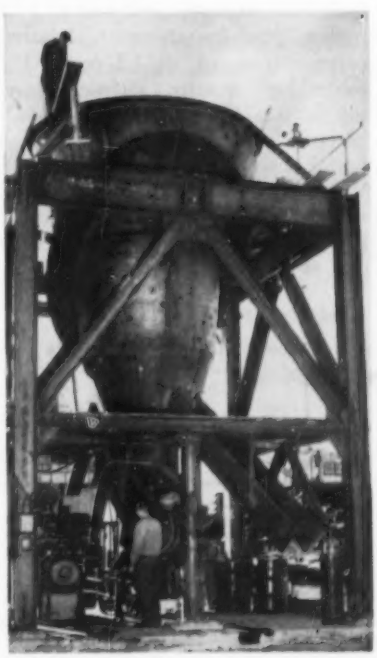
Early in 1955 that company earmarked $5 million for an intensive 2½-year oil shale research program, aimed at learning if marketable products from shale oil can be produced from its Colorado shale deposits at a cost competitive with those obtained from crude oil.

In a recent statement, the company made this comment: "We believe we have reached the point where the higher and increasing costs of discovery of new sources of crude oil are making more attractive the development of a shale oil industry."

The analysis started last year, the company now feels, is justified by four factors:

1. The Bureau of Mines, some years ago, demonstrated a method for low-cost, efficient mining of the shale.

2. During and immediately after World War II, Union Oil conceived and built two workable pilot models of retorts to extract the oil.



Union Oil Company's mock-up of their commercial shale retort. This pilot plant, constructed in the latter part of 1955, was used to study stresses and to obtain various design data. The commercial size unit, when built, will be from two to three times the size of the mock-up. The retort is designed ot handle shale ranging in size up to 6 inches.

3. The company's Unifining process of reducing crude oil impurities, perfected during the last two years, has provided a new technique for converting virgin shale oil into good feed stock for conventional refineries.

4. Discovery costs of new domestic crude oil reserves recently have tended to approach or exceed the estimated cost of recovering oil from shale.

The company currently is constructing a full-scale, commercial size retort and all auxiliary facilities which is to be operated near Grand Valley, Colorado. Research work dealing with conversion of raw shale oil obtained from shale retorting to high quality marketable oil is being carried on simultaneously at the company's Research Center at Brea, California.

The company's oil shale properties near Grand Valley, Colorado, are very rich and reasonably accessible. It is conservatively estimated that the richest part of the shale deposits (Union's) contain approximately five billion barrels of recoverable oil—roughly eight times the company's current proved crude oil reserve.

The full scale commercial version of the Union Oil retort has been designed and is now being constructed by the general contractor, the Stearns-Roger Manufacturing Company of Denver. The auxiliary equipment for the retort has been purchased. A site for the plant has been cleared on the company's Parachute Creek property in Colorado, buildings have been erected and the rock crushers and conveyors are being installed. An all-weather road has been constructed from the retort site to the mining elevation in the shale cliffs. The mining contractor is currently preparing the mining face. It is expected that the retort will be in operation some time this summer (1956).

The research on methods of refining shale oil is well under way at the Brea (California) Research Center of the company. Special research equipment has been designed and built and extensive refining tests now are going on. The company reports that, generally speaking, after 14 months' work, they are on schedule, with both problems and progress occurring about as expected. Total expenditures thus far are slightly over $1,500,000. ##

What's All the Controversy About

One Side Says . . . 'Define octane numbers above 100 in units of performance numbers. For blending and sensitivity calculations, convert octane numbers below 100 to performance number.'

Here's Why It's Important to the Refiner . . . and the Case for Performance Numbers

L. W. Moore
American Oil Company
New York City

ANTIKNOCK QUALITY is the most important competitive property of the refiners' major product. It is a matter of basic economics that when the refiner expends money to raise octanes and thereby to gain or maintain a competitive advantage, he wants that improvement to be useful and significant to the consumer. Only under such circumstances can he expect the consumer to pay for part, or preferably all, of the improvement costs. Today the refining industry is spending large amounts of money on octane improvement processes. For example, American Oil Company and its affiliates during the past 18 months have expended about $30 million for the improvement of octane quality. Shown in Figure 1 are several common methods currently used in the refining industry to upgrade the quality of gasoline. Tetraethyllead addition is probably the most familiar method of increasing octanes. However, the use of TEL is limited and it becomes necessary to install more costly processes, such as reforming and extraction, as higher octane levels are required.

Table 1
Octane Improvement Processes

TEL Addition
Thermal Reforming
Catalytic Reforming
Solvent Extraction & Thermal Reforming of Raffinate

Presented in Table 2 are investments and costs of barrel octanes incurred by a 50,000-barrel per stream day refinery for several individual octane improvement processes. Barrel octane costs above 100 shown in this figure were based on the GM extension scale. Of the octane improvement methods shown, tetraethyllead offers the cheapest source of octanes at current premium octane levels. Each additional increment of octane quality becomes increasingly more expensive to the refiner. A thermal reforming unit installed at an investment cost of $3.5 million produces incremental barrel octanes at a cost of 7.3 cents. The use of high severity catalytic reforming with its platinum catalyst and 20 percent loss in volume results in a barrel octane cost of about 11 cents. When solvent extraction is required, the cost of barrel octanes increases still further, to a level over five times the cost of ethylizing.

Table 2
Investments & Octane Costs

Process	Investment Cost M$	Barrel F-1 Cost ¢
TEL Addition.....	..	3.4
Thermal Reforming..	3.5	7.3
Catalytic Reforming.	6.3	11.0
Solvent Extraction & Thermal Reforming of Raffinate.....	2.3	18.5

In this situation of high and increasing costs, it is obviously preferable to measure this antiknock property by rating methods of high precision and in units related to its value. Ideally the relationship should be linear over its entire range. Then we would have a situation such as prevails in the gas industry where price is based solely on heating value. Unfortunately, the value of motor gasoline in the automotive engine is not so simple a function of a single property.

In addition to the advantage of a sound, uniform scale from the marketing standpoint, consider the manufacturing problem. Refining today is a complex as well as costly affair. Many choices are open among the processing routes and the multiple units of today's large refinery. The selection is usually made on the basis of economics—day to day or long range—the investments, yields, and operating costs all contributing.

In order to carry out these economic calculations rapidly and conveniently as they relate to octane number, it is essential to use a scale which is technically sound and as uniform as possible. A scale which results in refining costs having the same order of magnitude in both the premium and regular octane range is desirable.

We certainly would prefer not to have a broken scale which would result in refining costs of, for example, 3 cents per barrel per unit for premium gasoline and 7 cents per barrel per unit for regular gasoline. If other considerations dictate the adoption of a broken scale—say, octane numbers up to 100 and performance numbers above—you may be sure that the economists in the refinery will convert one or the other to achieve linearity or at least continuity.

Choice of Scale—The author is sure an infinite number of scales for

AntiknockScalesOver100?

The Other Side Says **. . . 'Extend octane scale smoothly and continuously through the 100 octane number. Retain present scale below 100.'**

measuring antiknock quality of fuels having knock-limited performance values greater than iso-octane could be developed.

• One method is to extend the octane scale smoothly and continuously through the 100 octane number. Examples of this are the CRC and GM octane scale extensions.

• Another method is to define antiknock quality above 100 octane number in units of performance number. It appears to us that this has several advantages from the refiners' viewpoint. Although developed for aviation fuels, this scale seems to offer a technically sound and uniform basis for extending the antiknock scale for automotive fuels.

The numbers would be significant because of their proportionality to power. The performance number scale is familiar to refiners and engine manufacturers since it has been used many years in controlling aviation gasoline quality. Adoption of performance number scale above 100 for motor fuels as well as for aviation fuels would eliminate the necessity of having two scales in use for high octane fuels.

Assuming the performance number scale is adopted for defining antiknock quality above 100, distributors and retailers would continue to use the existing octane scale up to 100. They would change over to performance numbers only when fuel quality exceeds the 100 octane level. Antiknock quality below 100 can also be defined in terms of performance numbers.

Thus, for blending or sensitivity calculations, the refinery economist and the fuel quality expert could convert octane numbers below 100 to performance number and have a continuous relationship through the 100 octane point. They would also have the alternative of converting performance numbers to some other blending octane scale of their own choosing. Such a procedure is employed currently in the blending of aviation gasolines.

To demonstrate the utility of the performance number to the refiner, the variation in cost of octanes of the entire gasoline pool was calculated at several octane levels for a modern refinery processing 50,000 bpsd of crude. Existing process units in this base refinery included crude distillation, catalytic cracking, polymerization, alkylation, and visbreaking. All alkylate produced went to aviation gasoline. Premium gasoline consisted of 30 percent of the total motor gasoline pool. The maximum octane level of premium gasoline produced in the base refinery was 97.0 Research and regular gasoline was blended to 90.0 Research.

To raise the octane level of premium gasoline above 97, a catalytic reformer was installed. All available virgin naphtha was reformed, producing clear 100 Research reformate. The reformate was split with the heavy portion blended to premium and the light to regular.

To maintain proper volatility, catalytic gasoline was fractionated and the light portion blended to premium. The installation of this octane improvement process allowed the premium level to be increased to 107.8 performance number (102.6 Research GM octane scale), while maintaining a spread of 7 Research octanes between premium and regular.

In order to be in line with past practice in the industry, an octane scale was used below 100 in setting the premium-regular spread. Octane units above 100 were defined by the GM extension of the octane scale and are equivalent to three performance numbers.

The installation of solvent extraction and thermal reforming units increased premium level to 110.3 performance number. The charge stock to the extraction unit was light catalytic reformate. The raffinate from this unit was thermally reformed. The extract was blended in premium and thermally reformed raffinate went to regular.

Shown in Figure 1 is the relationship between costs of octanes and premium octane level. These costs are based on increasing the octane level of the total gasoline pool with regular gasoline maintained at the fixed margin below premium.

• Costs shown between premium

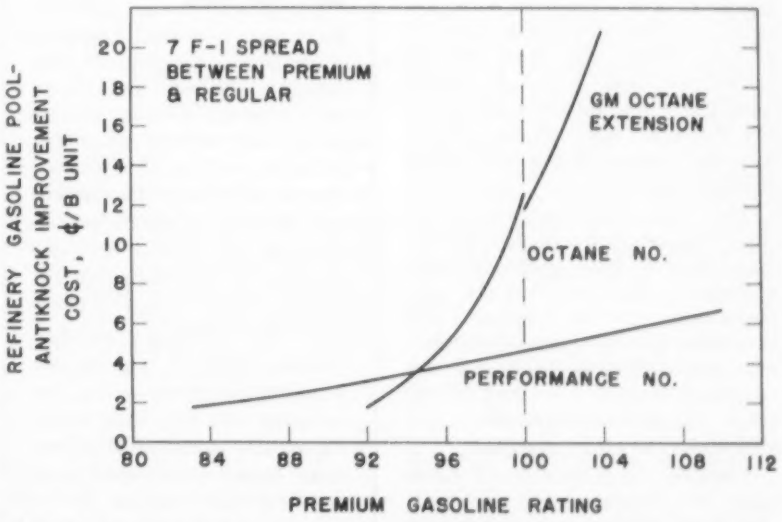


FIGURE 1—Cost of antiknock improvement varies widely per unit, using research octanes and the GM extension.

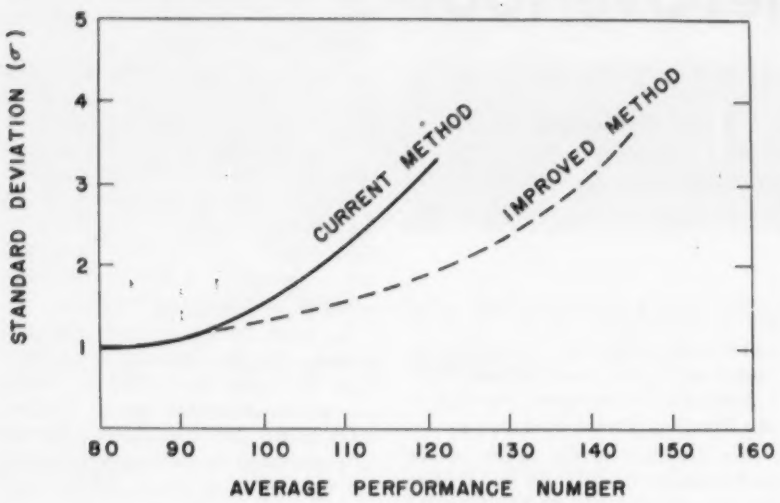


FIGURE 2—Precision of test method: More important than the selection of a scale.

octane levels of 92 and 97 Research represent the addition of the last 2.1 cc TEL.

• The costs between 97 and 102.6 Research represent catalytic reforming and fractionation of reformate.

• Above 102.6 the costs are for octanes obtained using solvent extraction and thermal reforming of the raffinate.

It is shown by these curves that the cost per unit, using research octanes and the GM extension, varies widely. Up to 96, it is 3 cents per barrel per octane and then rises rapidly up to 15-20 cents in the range above 100. The exact cost will, of course, depend upon the octane extension scale used. On the other hand, the use of performance number gives a more nearly constant cost.

Thus from the standpoint of refinery economics, use of the performance number scale results in more uniform quality costs over the antiknock range than the CRC and GM extensions. For every unit of performance number increase likely to be encountered during the next several years, the incremental refining cost is of about the same magnitude.

Therefore, from the refiners' standpoint, the performance number scale has considerable merit for defining the antiknock quality of gasolines above the 100 octane level. In order to avoid anomolies in cost calculations and in sensitivity calculations, however, it must be used below 100 as well as above.

The Precision Problem—While the scale used to define antiknock quality is important to the refiner, and he would like to have it as representative of refining costs as possible, the scale is not as important as the precision of the method and the costs which can be incurred due to poor reproducibility. Improvement in the precision of the test method for measuring antiknock quality at present and future octane levels can result in appreciable savings to the refining industry.

In a paper presented by M. R. Morrow of Humble at the St. Louis API meeting in May 1955,[1] it was pointed out that, at octane levels current then, significant improvements in the precision of laboratory knock test methods could reduce the cost of motor gasoline produced in the U. S. by $12 million per year. In the future, with the rising costs of antiknock quality and increased volume, improvements in the precision of laboratory knock test methods can reduce the cost of motor gasoline blending even more.

The high octane reproducibility group of ASTM Research Division I recently carried out a program to determine the reproducibility of octane ratings above 100. Knock ratings obtained on 16 fuels, by bracketing with reference fuel blends, were found to have the precision shown in Figure 2. Here precision is expressed in terms of standard deviation. Performance number precision is shown to deteriorate rapidly above a performance number of about 105. During the course of their work, the ASTM study group developed an improved method for operating the CFR test engine which resulted in improved precision as indicated in Figure 2. Presumably, this order of precision is the best that can be expected with the present equipment.

To illustrate the value to the refiner for improving precision, let us examine a case where the refiner is interested in producing a premium gasoline having a minimum performance number of 110. At this premium gasoline quality level, the cost of a barrel performance number is 9.9 cents. The cost in Figure 1 of 7 cents

Meet the Author

L. W. MOORE went to work for Standard Oil Company (Indiana) at its Whiting refinery in 1933, following his graduation from Massachusetts Institute of Technology. In 1935, he was transferred to Pan American Petroleum and Transport Company at its New York office. In that company, he was assistant to the president, manager of research and manager of manufacturing, and in 1948 he was elected president of Pan American Refining Corporation. In 1953 he was elected first vice president of Pan American Petroleum and Transport Company. The following year, when Indiana Standard acquired the Transport Company and a new company was organized under the name of American Oil Company, Moore was elected as its executive vice president.

per barrel performance number is for a pool gasoline from which the premium gasoline is 110 performance number. Due to the normal variations in the knock test method, some blends which are below refinery specification in true quality are rated above specification and are approved for shipment. In order to avoid or minimize such cases, the refiner must blend to a higher target than his minimum specification.

Statistics tells us that a value obtained by a single determination has to be 1.65 standard deviations above the minimum acceptable value for the true value to be above this minimum 95 percent of the time. The average of four independent determinations should be 0.83 standard deviation above the minimum acceptable value for the true value to satisfy the minimum 95 percent of the time. This means that if a minimum of 110 performance number is specified, it would be necessary to blend to approximately 112 performance number, using the current method and four independent determinations.

Figure 2 shows the margin of safety, in terms of performance numbers above 110, to which the refiner must blend in order to ensure that shipments meet minimum specifications 95 percent of the time. It is shown that some improvement in precision can be gained by multiple determinations.

Assuming some optimum number of ratings is made to achieve this precision, the loss incurred by the refiner due to this excess antiknock quality is shown in Figure 4. For example, with four individual ratings on each blend, the gain in precision resulting from going to the improved test method versus the present test method will decrease the loss incurred due to octane giveaway from 18 to 13 cents per barrel. This represents an annual savings to the industry of over $20 million. This does not include the additional savings due to improvements in blending procedure which would result from improved test precision. Of course, the cost of multiple testing and any delays in shipment would offset this saving.

Now it is recognized that refiners do not actually blend to such a wide margin above their specifications. More commonly they set their octane target to avoid customer complaints and to match competition. If we assume that any complaints are due to a few batches which were low and went out undetected, however, the cost of the poor precision is still there, even though it is hidden. If the abnormal batches could be eliminated by more precise ratings, the target octane level could be lowered correspondingly. In view of the magnitude of these potential savings, work on the development of test method improvement should be given highest priority, even though a scale for antiknock ratings above 100 octane number has not been approved.

In summary, it is felt that the performance number gives a good indication of both available power for the consumer and cost of quality to the refiner. It should represent a satisfactory basis for standardization above 100 octane, although it must be recognized that such a move will cause the technical people in their refinery work and in publishing technical papers to use performance numbers below 100 as well. In addition, our efforts should be intensified on the development of an improved method for measuring antiknock quality above 100 octane number regardless of whether this requires a new fundamental approach to antiknock rating or merely refinement of the present methods.

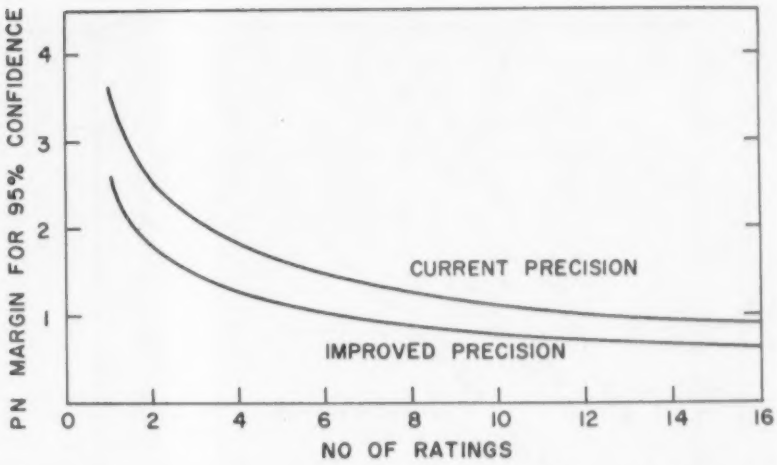


FIGURE 3—Precision at 110 performance numbers: Some precision gained by multiple determination.

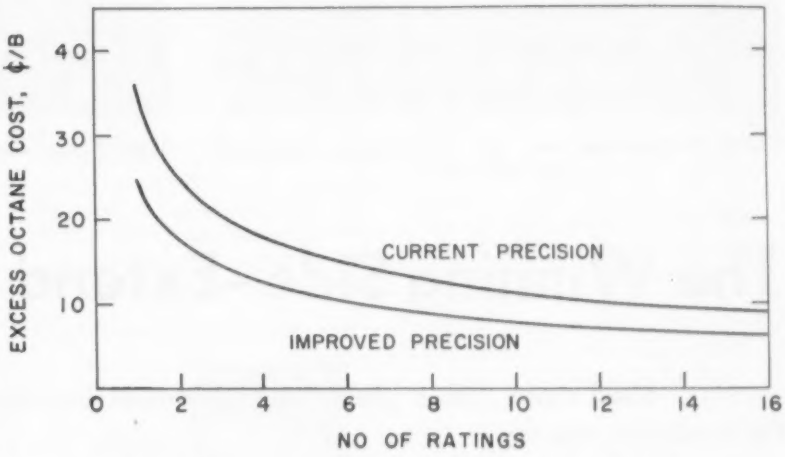


FIGURE 4—Variation in cost with precision: $20 million at stake?

Presented at Midyear Meeting, API Division of Refining, Montreal, May 16, 1956.

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Antiknock Scales

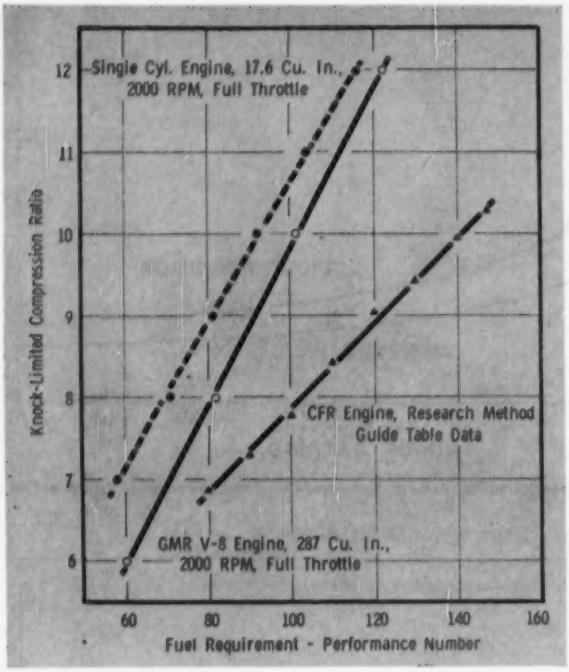
Single Cyl. Engine, 17.6 Cu. In.,
2000 RPM, Full Throttle
CFR Engine, Research Method
Guide Table Data
GMR V-8 Engine, 287 Cu. In.,
2000 RPM, Full Throttle
Knock-Limited Compression Ratio
Fuel Requirement - Performance Number

FIGURE 1—Compression ratio and fuel antiknock requirement: Essentially linear.

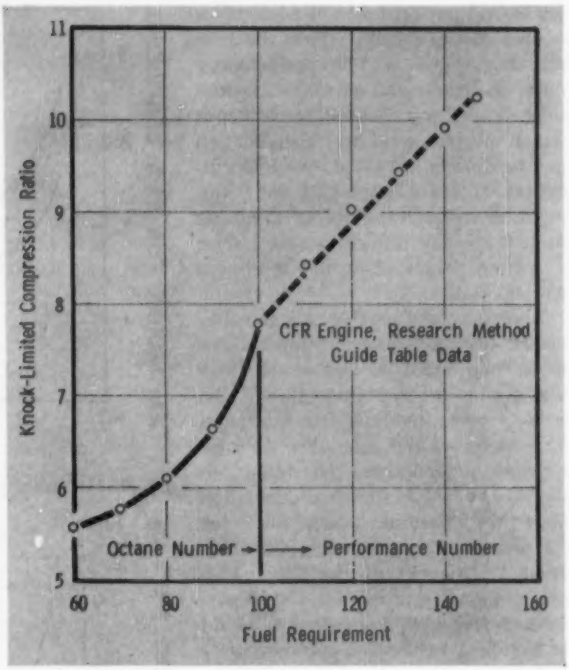

FIGURE 2—Performance number extension scale: Discontinuity at 100 is too large.

The Winning Side—Extend Octane Scale

Used more than a year, General Motors has found this method satisfactory for antiknock quality.

Warren M. Wiese
General Motors Corporation
Warren, Michigan

FOR THE PAST year General Motors has been using the relationship—

$$\text{Octane Number} = 100 + \frac{\text{PN} - 100}{3}$$

where PN = Army-Navy Performance Number, to describe the antiknock quality of fuels above 100 octane. This relationship is used as a direct extension to the present octane number scale and the numbers above 100 are called octane numbers.

Based upon our experience, we believe that these octane numbers satisfactorily describe the antiknock quality of fuels above 100 octane with respect to the additional engine performance available from one octane number anywhere in the antiknock range from 100 octane to isooctane plus 6 cc. TEL per gallon. More specifically, we feel that these octane numbers bear an approximately linear relationship to knock-limited compression ratio in naturally aspirated automotive type engines.

It has been customary to express antiknock quality above 100 octane in terms of the concentration of TEL in isooctane required to produce the same knock intensity as the test fuel. This method of expression is unsatisfactory because the numbers above 100 bear no established relation to the numbers below 100. In other words, it has been impossible for the automotive engineer to think of antiknock quality in the same terms both above and below 100 octane numbers.

Early in 1955 it became apparent that we needed a better scale with which to define octane quality above 100. We needed this scale in order to characterize the octane requirements of our experimental high compression engines in a manner that would have a significant meaning to all concerned. We needed it so that we could talk among ourselves with a common language.

There are two ways to handle the problem; one was to ignore the past 25 years' work and experience and adopt an entirely new scale, the other was to adopt an extension scale which would utilize present knowledge. It was decided to make use of the information and experience available to us by adding on to the present octane scale.

We also believe that it would be beneficial to the automotive and petroleum industries as a whole if a standardized octane scale extension were to be adopted in the near future.

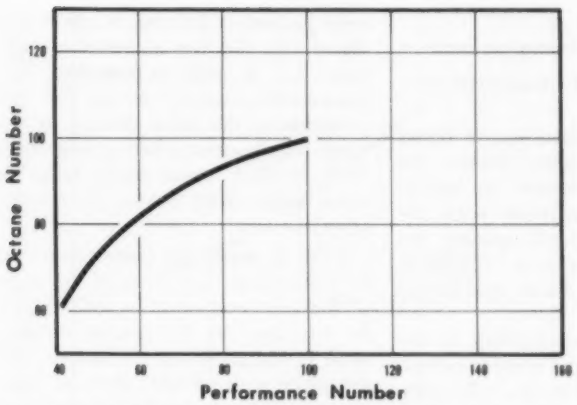

FIGURE 3—How present octane number scale and performance number are related.

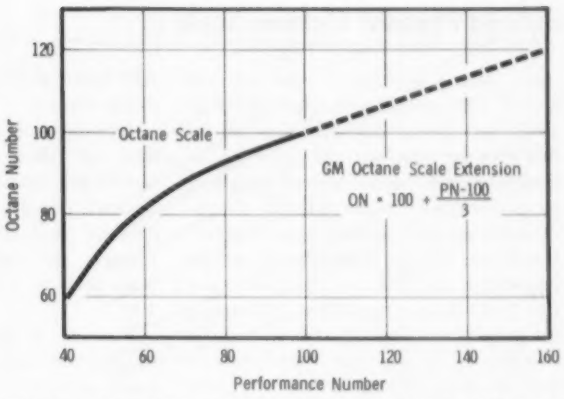

FIGURE 4—Extended octane number scale: Continuous with octane number scale and linear with respect to knock-limited engine performance.

A standardized scale would protect our customers as well as ourselves from the confusion that would arise out of the use of several independent systems.

Ideal Antiknock Quality Scale—The characteristics of an ideal antiknock scale are difficult to describe. Various individuals and organizations have unique requirements which they would like to see incorporated into an ideal antiknock scale. From the automotive engineer's viewpoint, the most important requirement is that the scale should provide numbers that are proportional to some measure of engine performance. That is to say that the numbers should be a direct indication of the additional power, thermal efficiency, or other benefits that could be derived from extra fuel octane quality through proper engine design practices.

Consideration of these requirements for an ideal scale points toward long term study of the fundamental factors involved in engines, fuels and the combustion process. Much time will be spent before these fundamentals will be understood and made usable.

Requirements for a Practical Octane Scale Extension—Since no Utopian system for expressing antiknock quality was available, it was decided to develop a *practical* extension to the present octane scale.

We feel that there are four major requirements for a practical extension to the octane scale.

1. It should retain the use of the present octane number scale up to 100. This is a practical requirement because the octane number scale is standardized, is universally used, and is satisfactory in that range.
2. It should be defined in terms of the antiknock quality of blends of isooctane and TEL. This is convenient because blends of TEL in isooctane are being used universally as reference fuels in the region above 100 octane.
3. It should be continuous with respect to the present octane number scale. This means that the numbers immediately above and below 100 should have the same meaning relative to engine performance, or in other words, they should be the same size.
4. It should be linear with respect to some measure of knock-limited engine performance, or to phrase it differently, should provide numbers of about the same size throughout its length.

A fifth factor which could also have been listed was that the scale should be available immediately without requiring excessive development time.

Army-Navy Performance Numbers—During the period from World War II until the present, approximately a dozen proposals were made to CRC and to other cooperative organizations concerning extension or revision of the octane scale. Each of these proposals was considered in the light of the requirements outlined above. One of these proposals—Army-Navy Performance Number—showed considerable merit. Performance Number has been reported to be linear with respect to knock-limited compression ratio in naturally aspirated engines. Furthermore, it is officially defined in terms of the antiknock quality of blends of TEL in isooctane. Because of these two unique properties, Performance Number was considered as an octane scale extension.

The Performance Number scale was developed to provide a continuous scale above and below 100 octane that would allow the antiknock quality of aviation fuels to be expressed by numbers that were proportional to knock-limited engine performance. The scale was developed in two sections, one for fuels knocking *less* than isooctane and one for fuels knocking

Meet the Author

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more than isooctane. The section above 100 octane was established in 1942 by the Army Air Corps[1] by determining the percent increase in knock-limited engine power obtained in a series of supercharged multi-cylinder aircraft engines under takeoff conditions by the addition of various quantities of TEL to the iso-octane test fuel. Engine power, when using isooctane, was considered to be the baseline. The average curve drawn through all of the test points was used to define the Performance Number scale above 100 octane. The scale above 100 octane is officially defined by a tabulation[2] of TEL concentrations is isooctane and the corresponding Performance Numbers.

Below 100 octane numbers, the Performance Number scale was established in a similar manner based upon knock-limited performance of supercharged aviation engines and is defined by the relationship—

$$PN = \frac{2800}{128 - ON}$$

Accordingly, we can say that Army-Navy Performance Number is by definition proportional to knock-limited performance of supercharged aircraft engines.

In recent years, it has been shown that *Performance Number is also linear with respect to knock-limited compression ratio in naturally aspirated automotive type engines.* This relationship is shown in Figure 1 where knock-limited compression ratio is plotted against fuel antiknock quality in Performance Numbers for three automotive type engines.

The upper curve represents data taken on a 17.6 cubic inch single cylinder engine operating at 2000 rpm, full throttle. The middle curve represents data taken from a GM Research 287 cubic inch V8 engine operating at 2000 rpm, full throttle. Data for these two curves were taken from Hesselberg and Lovell's paper[3] on "The Potentialities of Fuel Antiknock Quality." The lower curve represents data for a CFR engine taken from the guide tables[4] for the ASTM Research test method below 100, and from the "Unofficial Guide Table Extension"[5] for the Research test method above 100. These latter data are average values obtained from several laboratories by the ASTM-DCC High Octane Reproducibility Group.

Examination of these curves shows that all three engines exhibit an essentially linear increase in knock-limited compression ratio with increased fuel antiknock quality expressed in Performance Numbers. This is true both above and below 100.

Because of the desirability of retaining the use of the present octane scale, use of Performance Number both above and below 100 was not feasible. However, because of its unique properties, use of the Performance Number scale above 100 as an extension to the octane scale appeared attractive.

Figure 2 shows the relationship between knock-limited compression ratio and fuel antiknock quality when using Performance Number only as an extension to the octane scale.

The data shown are for a CFR engine and were taken from the guide tables[4] for the ASTM Research test method below 100, and from the "Unofficial Guide Table Extension"[5] for the Research method above 100. Fuel antiknock quality is expressed in octane numbers up to 100 and in Performance Numbers above 100.

The curve indicates that Performance Number per se is not a satisfactory extension for the octane number scale because of the large discontinuity at 100. The numbers are much larger below 100 than above 100. This means that a one number increase in octane quality allows nearly three times the increase in knock-limited compression ratio just below 100 that it allows just above 100. To the automotive engineer this is most undesirable. The automotive engineer would like approximately the same change in octane requirement when going from 10:1 to 11:1 compression ratio as when going from 9:1 to 10:1 compression ratio!

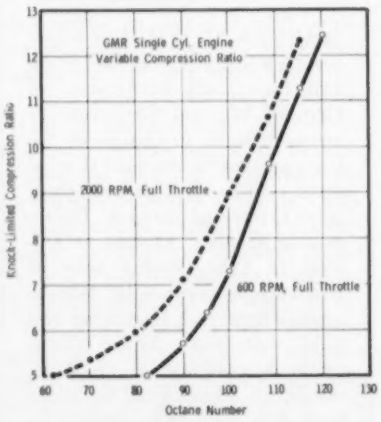

FIGURE 5—Compression ratio and octane number: Non-linear below 100 but linear above 100.

A most important observation can be made from this curve. If the slope of the extension could be made equal to the slope of the octane number scale in the region of 100 octane, the complete scale would then be continuous. The extension would also retain its linearity with respect to knock-limited compression ratio since only the slope would be changed.

General Motors Octane Scale Extension—Let us now consider how we can logically change the slope of the extension so as to obtain a continuous scale and still keep the extension linear with respect to knock-limited compression ratio.

In order to separate the development of the extension scale from the operating characteristics of a single engine, we need a general expression to represent knock-limited compression ratio that applies equally well to all automotive type engines. Performance Numbers will be used for this purpose since it was shown in Figure 1 that they are linear with respect to knock-limited compression ratio.

As background information, Figure 3 shows the relation between the present octane number scale and Performance Number.

Remembering that Performance Number in this case represents knock-limited engine performance, it can easily be seen that the size of an octane number in terms of knock-limited performance increases as you approach 100 octane. In order to make an extension scale that is continuous with the octane scale and to maintain a linear relationship with respect to knock-limited engine performance, a straight line was drawn between the 95 and 100 octane number points and was extended out to the level of engine performance represented by 161 Performance Numbers. This is shown on Figure 4.

The slope of the extension line drawn through the 95 and 100 octane points was very nearly three. For convenience, a value of three was used to write the simple formula—

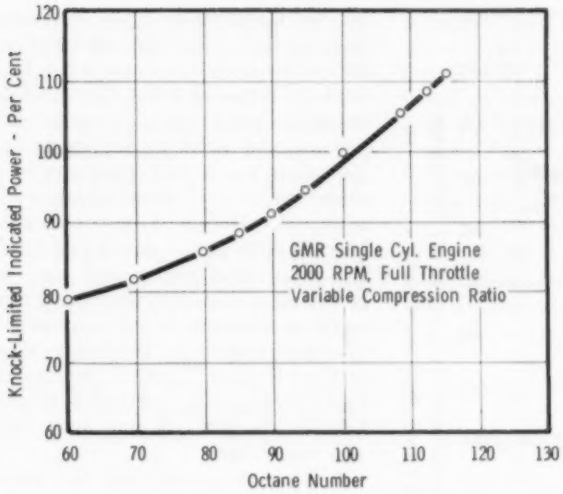

FIGURE 6—Power and octane number: Reasonably linear above 100 octane.

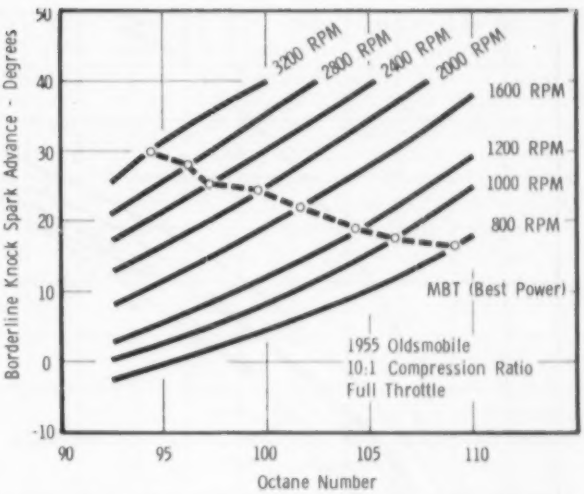

FIGURE 7—PRF framework for road octane rating: Relationship is sufficiently linear to provide a good framework for fuel purposes.

$$\text{Octane Number} = 100 + \frac{PN - 100}{3}$$

to define the octane numbers above 100. This scale is our compromise to best match the practical requirements for an octane scale extension at the present time.

Octane Scale Performance—It has long been said that the proof of the pudding is in the eating! Therefore, let us examine some engine test data to determine how well the extended octane scale performs.

Figure 5 shows the relationship between knock-limited *compression ratio* and fuel anti-knock quality in octane numbers for a GM Research single cylinder variable compression ratio engine.

The upper curve was obtained at 2000 rpm, full throttle, and the lower curve at 600 rpm, full throttle. The data points above 100 octane are connected by straight line segments to show actual test variations. These are unpublished data obtained by J. M. Campbell in 1939.

Note that although the data show a non-linear relationship between octane number and knock-limited compression ratio below 100, they are essentially linear in the region above 100 octane. The curves also are continuous in the region of 100 octane. In other words, we have succeeded in extending the octane scale in such a manner as to provide the same allowable change in knock-limited compression ratio per octane number in the range from 100 octane to isooctane + 6 cc. TEL as exists currently in the range from 95 to 100 octane number.

Figure 6 shows the relationship between knock-limited *power* and fuel antiknock quality in octane numbers for the GM Research single cylinder variable compression ratio engine. The ordinate of the graph shows knock-limited indicated power in percent based upon a figure of 100 percent for a fuel of 100 octane number. These data were obtained by J. D. Caplan in 1952.

The curve indicates that knock-limited power obtained by increasing compression ratio is also reasonably linear with respect to octane number quality in the region above 100. However, knowing that engine power does not usually increase linearly with increasing compression ratio we would expect this relationship to flatten somewhat if it were extended to higher octane number levels.

Another interesting observation that can be made from this relationship is that an increase in compression ratio which increases the octane number requirement of this engine from 100 to 110 octane numbers, provides an increase in knock-limited power of 8 percent. This average gain of 0.8 of 1 percent in power from an increase of one octane number in fuel quality is barely measurable with modern dynamometer equipment since it amounts to only 2.4 horsepower even in the case of a 300 horsepower engine. In other words, it would seem foolhardy to make the antiknock quality units so small that they cannot be readily measured.

Another relationship that is important to the automotive engineer is the relation between knock-limited spark advance and fuel antiknock quality. Figure 7 shows this relationship in the form of a primary reference fuel framework for road octane rating of fuels in a 1955 10:1 compression ratio Oldsmobile car. The Modified Borderline Technique was used to obtain these data.

The solid lines show the relationship between spark advance for borderline knock and fuel octane number quality at several engine speeds from 800 to 3200 rpm. The dashed line shows the spark setting for best power operation at each test speed.

Figure 7 demonstrates that the spark advance-octane number relationship above and below 100 octane is continuous and is sufficiently linear to provide a good, usable framework for fuel rating purposes in modern full-scale engines.

Original presentation was before the National Petroleum Association, Cleveland, April 20, 1956.

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[2] ASTM, Manual of Engine Test Methods for Rating Fuels, Aviation Method D-614.
[3] Hesselberg, H. E. and Lovell, W. G., "The Potentialities of Fuel Antiknock Quality," presented at SAE National Fuels and Lubricants Meeting, Tulsa, Oklahoma, November 10, 1950.
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[5] Unofficial Guide Table Extension—ASTM Research Method D-908, ASTM-DCC High Octane Reproducibility Study Group, April 1955.

Antiknock Scales

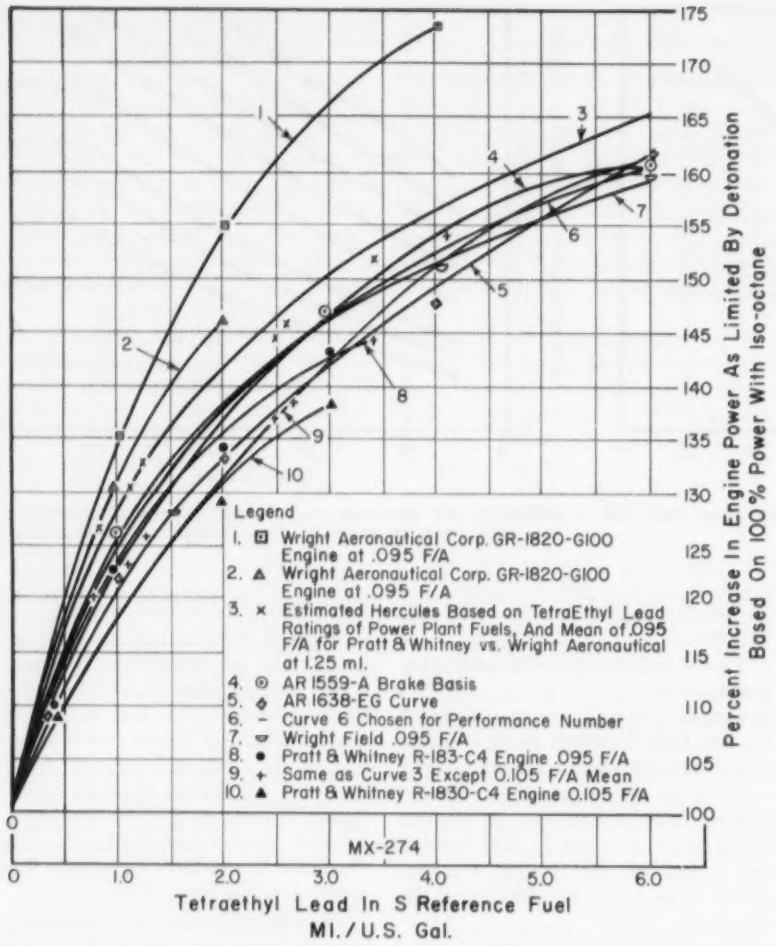

Legend
1. Wright Aeronautical Corp. GR-1820-G100 Engine at .095 F/A
2. Wright Aeronautical Corp. GR-1820-G100 Engine at .095 F/A
3. Estimated Hercules Based on TetraEthyl Lead Ratings of Power Plant Fuels, And Mean of .095 F/A for Pratt & Whitney vs. Wright Aeronautical at 1.25 ml.
4. AR 1559-A Brake Basis
5. AR 1638-EG Curve
6. Curve 6 Chosen for Performance Number
7. Wright Field .095 F/A
8. Pratt & Whitney R-183-C4 Engine .095 F/A
9. Same as Curve 3 Except 0.105 F/A Mean
10. Pratt & Whitney R-1830-C4 Engine 0.105 F/A
MX-274
Tetraethyl Lead In S Reference Fuel
Ml./U.S. Gal.
Percent Increase In Engine Power As Limited By Detonation Based On 100% Power With Iso-octane

FIGURE 1—Effect of increased antiknock value on permissible engine power under take-off conditions: curve 6 was chosen for "Performance Number."

New Developments in Antiknock Scales

Here's an up-to-date status report on proposals made and the questions still to be answered.

T. B. Rendel
Shell Oil Company
New York City

CERTAIN BASIC decisions have to be made before an antiknock scale above 100 can be agreed upon. There is still time to consider new proposals. Here's how the scales have developed over the past 26 years.

The present octane number scale was adopted on September 15, 1930, by the Cooperative Fuels Research Steering Committee and was based on the earlier suggestions of the late Dr. Graham Edgar of Ethyl Corporation to use the pure hydrocarbons normal heptane and 2-2-4 trimethylpentane (iso-octane) as a pair of primary reference fuels for the standardization of antiknock testing. The scale was adopted after three years of endeavor and cooperative testing and after a great deal of discussion concerning the merits of a number of different methods for expressing the antiknock value such as Highest Useful Compression Ratio or Maximum Allowable Spark Advance, benzene equivalents or toluene equivalents.

At that time extending the scale beyond 100 was considered very much an academic subject. A proposal was made to extend the scale, if and when necessary, by adopting the value of 200 for some high antiknock component such as alcohol or benzene. This proposal, however, received its death blow when it was found in 1932 that alcohol rated only 91 by the then newly developed motor method and that the rating of benzene was extremely susceptible to the test conditions.

During the middle 1930's the development of high antiknock fuels was extremely rapid, sparked largely by the development of processes to produce iso-octane commercially, and in 1939 100 octane aviation gasoline was in large scale commercial production. For aviation fuels, therefore, it became very necessary to develop a scale which would classify fuels over 100. Particularly was this the case since it was known that under certain operating conditions, such as occurred in a supercharged aviation engine running with very rich fuel air mixtures, the antiknock behavior of several commercial fuels was considerably better than iso-octane.

Army-Navy Performance Number—On September 13, 1938, the CFR Aviation Fuels Division was authorized to appoint a group leader to collect and correlate ideas on the extension of the octane number scale, and in a progress report dated January 27, 1939 on "Octane Scale Extension Project" the CFR Group Leader responsible listed and discussed eight different methods by which extension of the octane scale might be accomplished. Among the eight methods resulting from his dis-

cussions with representatives from interested organizations were the following:

1. Addition of a fixed quantity of tetraethyllead to the present reference fuels, both primary and secondary.

2. Use of a new high reference fuel of a higher antiknock value than iso-octane.

3. Addition of tetraethyllead to iso-octane, the rating being given in terms of iso-octane plus lead or in terms of some arbitrarily established value.

4. Extrapolation of the curve of compression ratio versus octane number.

5. Use of performance numbers—the performance number being obtained by dividing the engine output with a given fuel by the engine output with iso-octane and multiplying the result by 100.

6. Use of a scale based entirely on the full-scale engine calibration of the reference fuels, the calibration to be made in terms of some engine variable.

In July and August 1941, a Coordinating Research Council group met at Wright Field where correlation testing was conducted and agreement was reached that resulted in the supercharged knock test (F-4) method. Shortly after this the Military procurement, Specification AN-VV-F-748 (dated September 22, 1941) required that: "Knock ratings shall be expressed in terms of octane number (percent iso-octane in normal heptane) up to and including 100, and in terms of iso-octane plus milliliters of tetraethyllead per U. S. gallon in iso-octane above 100." Thus, another new test method had been adopted without concurrently adopting an extension of the number system above 100.

As a method of expressing antiknock value it was complicated and somewhat awkward to use for calculating blends and rating engines. It was desirable, therefore, to transform milliliters of TEL in iso-octane into a usuable set of numbers. As the only users of this type of fuel were the Military Services and three engine manufacturers producing the engines for these Services, a small group composed of the representatives of the Services, the engine manufacturers, and the Petroleum Administration for War, representing the producers, was set up and quickly came to an agreement as to a suitable method which later received the approval of the specification authorities in both the U. S. and the United Kingdom.

Meet the Author

T. B. RENDEL is vice president of manufacturing for Shell Oil Company. A graduate of Cambridge University, he joined Shell in 1927 as a motor-testing engineer at the company's Wood River, Ill., refinery. In 1936 he was promoted to chief research engineer at Wood River. At the outbreak of World War II, in 1936, he was appointed chief engineer of the Aviation department of the associated Asiatic Petroleum Corporation, and assisted in the staffing and construction of the Thornton Aero-Engine Research laboratory near Liverpool, England. From 1942-44 he was on a special assignment as principal technical officer of fuels and lubricants with the British Ministry of Aircraft Production office in Washington, where he did liaison work with U. S. service forces. Rendel returned to Shell in 1944 as technical assistant to the manager of the Marketing Aviation department, serving there until 1948, when he was assigned to the Lubricants department as technical assistant manager for automotive and aviation products.

Antiknock Scales

The method used was as follows: A family of curves representing percentage increase in power for various increments of TEL in iso-octane were prepared for various aircraft engines under various operating conditions, including some laboratory engines such as the CFR and 17.6 engines. The scattering of the data (Figure 1) was indeed notable and the line chosen to relate performance to lead content could be termed average only by courtesy.

The *original* Performance Number curve, Number 6 of Figure 1 was the smoothest curve that could be drawn by eye with the help of a given French curve through the best supported engine data. Unfortunately, it did not result in a completely smooth curve, nor did the simple tabulation derived from this curve permit extremely close interpolations to obtain numbers for intermediate reference fuel blends. As a result of this, Ethyl Corporation, through S. D. Heron, was asked by the Military Services (Bureau of Aeronautics and the U. S. A. A. F.) to prepare smooth values. These smooth values were issued by Ethyl Corporation in June 1944 and are now the officially accepted values where this scale is used.

The scale has proved very useful in rating aviation gasolines for their antiknock performance, and it has been adopted in all aviation specifications and by aviation gasoline producers of both the U. S. and England since 1942. It has stood the test of time remarkably well despite the fact that it is well known that it cannot be used to predict the increase in performance in any given case, and frequently the terms performance number and octane number above 100 have been used interchangeably.

Its chief disadvantage was that it made a serious break in the continuity of the two scales at the 100 point and this was a difficult situation for blenders of aviation stocks who had to calculate the value of a blend from stocks which had antiknock values above and below 100. In 1944 the Aviation Gasoline Advisory Committee (AGAC) developed some empirical extensions of the knock rating scale for the F-3 Aviation method and

New Developments In Antiknock Scales . . .

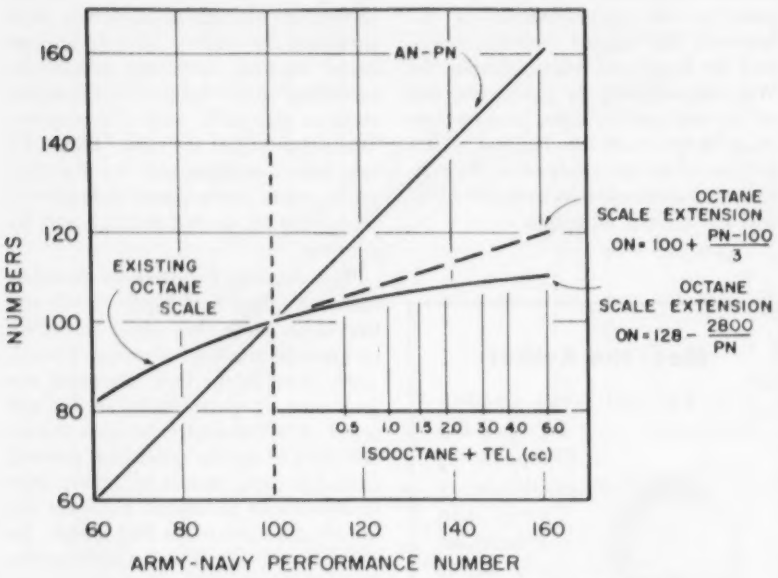


FIGURE 2—Antiknock extension scales: Still time to consider others?

the F-4 Supercharged method. Both scales were developed primarily to facilitate fuel blending calculations for which purpose they have proved very useful but neither scale was considered applicable for fuel specifications at that time.

Another way to overcome the continuity problem was to extrapolate the P.N. equation for values below 100. This was done by Mr. S. D. Heron of the Ethyl Corporation at the request of the Military Services in August 1944 and gave a set of performance numbers below 100 which could be related to octane numbers. The scheme has received a limited acceptance but has not been used in any fuel or engine specifications.

After the war many efforts were made to revise the aviation fuel rating scales to develop a common scale which did not have the break in continuity at 100. Several alternative reference fuels were considered such as 2-2-3 trimethyl butane (triptane) and heptane, or iso-octane-heptane toluene-blends and a constant amount of TEL. It was found that triptane was not available at a sufficiently attractive price. Furthermore, under certain test conditions its antiknock value was not sufficiently better than iso-octane to give a satisfactory extension.

A very comprehensive report was issued by the CFR Committee on these investigations (CRC Report dated April 18, 1948, Method for Expressing Antiknock Ratings). On the basis of this it was finally decided that the current reference fuels, iso-octane and normal heptane below 100 and TEL in iso-octane above 100 were the best available and that the method of expressing the results should be continued as in the past, i.e., AN Performance Numbers above 100 and Octane Numbers below 100, until a greater need for a change was shown.

At that time, of course, the antiknock value of motor fuel was well below 100 and the aviation industry was switching to gas turbines with the result that the development of high antiknock aviation fuels came to an abrupt halt. Nevertheless, the investigation was a very thorough one and many of the conclusions reached are still valid.

Investigations During 1948-1952—Since 1946, under the pressure of competition and to meet the demand of the automotive industry's ever increasing compression ratios, antiknock values of motor fuels have increased by leaps and bounds. From a value of somewhere around 75 in 1946, they are now, ten years later, knocking on the door which says 100. This means that certain stocks are definitely over 100, and it is of considerable importance to the research and development organizations, at least, of both the automotive and the petroleum industry to consider a suitable scale for measuring antiknock values at and over 100.

It may not be necessary yet commercially, but a common language to the manufacturing and research groups of both industries is obviously desirable if developments are to proceed smoothly. It is fully recognized that test method development must also go hand in hand with increasing antiknock values; but test method development means considering reference fuels which must be used over 100 and consequently methods of expressing the results obtained.

In 1952 at the urging of various research workers in this field, the CFR Committee's Motor Fuels Division gave considerable study to the question of extending the scale above 100. After six months or more discussion, a compromise agreement was reached to specify one octane number scale and one performance number scale for further study in the hope that further experience might lead toward a final decision which type of scale is most acceptable.

The two scales are illustrated in Figure 2 in comparison with the reference fuel compositions which they represent. The octane number scale above 100 was specified to be the value given by the formula:

$$\text{Octane No.} = 128 - 2800/\text{P.N.}$$

The Performance Number was specified to be the conventional aviation AN performance number above and below 100 as issued by Ethyl Corporation in 1944 as previously described.

Either of these two scales will provide sufficient continuity at the 100 point for approximating gasoline blends. However, large errors will occur if blends are calculated from ratings below 100 on one of these scales and ratings above 100 on the other. Neither these nor any other antiknock scales will give the exact ratings of all blends by proportion. This last statement should be noted

carefully. It is very true and applies to all antiknock scales, octane numbers included. Lack of appreciation of this fact has been the source of much confusion in the development of antiknock scales.

When the above suggestions had been made to the Motor Fuels Division in July 1952, further cooperative work was abandoned in favor of other and more urgent problems.

1955 Statement of Premises—Early in 1955, however, at the urging of several organizations who considered that the time had arrived for a further and perhaps more urgent study of this problem, the Motor Fuels Division of the CFR Committee organized a symposium at which every viewpoint and every antiknock scale and reference fuel was again discussed. The meeting occupied one full day's discussion which produced much useful data including much of the data already covered in past investigations. The records of these discussions were later embodied in a set of premises which were laid down before the Motor Fuels Division for its consideration and adoption. The premises were set forth in the knowledge of all the previous work in the CFR Aviation Fuels Division, and the 1952 discussions of the CFR Motor Fuels Division, as well as the discussions at its 1955 Symposium.

At the same time, Research Division I of ASTM Committee D2 also took up this problem, particularly from the viewpoint of test method development and the need for improvements in the Research and Motor Method tests in the higher antiknock ranges.

Arrangements were made whereby the views and discussions of the CFR Committee were given to the ASTM group and a close coordination of the two groups was established. Early in their work the ASTM group adopted the same premises as the CFR group and proceeded along parallel lines to work out their suggested method of expressing antiknock values over 100.

It was thought at the time these premises were stated they would be acceptable to all organizations concerned. However, since then they have been challenged by some groups and it is perhaps desirable to set them forth clearly so that they can be fully understood before proceeding

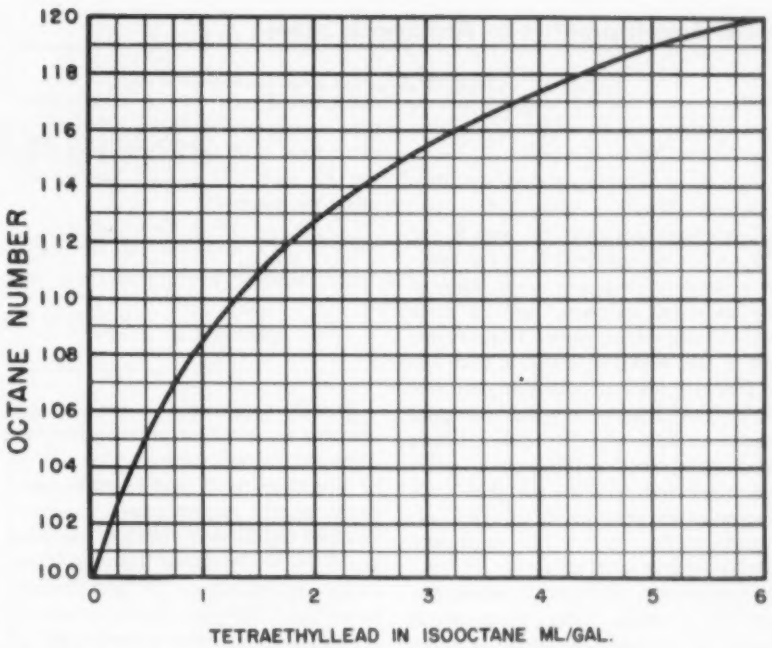


FIGURE 3—Iso-octane plus TEL and octane numbers above 100: Formula for curve has been derived.

with a discussion of the actual recommendations which resulted from the subsequent work of these committees. The premises stated by the Motor Fuels Division and ASTM groups are as follows:

1. The present octane scale below 100 should be retained.

2. The octane scale below 100 should continue to be defined in terms of normal heptane and iso-octane. The scale above 100 should be defined in terms of iso-octane and tetraethyllead.

3. The octane number scale extension should be continuous with the octane number scale in the region of 100.

4. The octane number scale extension should have a definite relation to engine performance in the region above 100.

It is possible that these conclusions were adopted prematurely and further discussions by the appropriate committees in industry will undoubtedly clarify this point.

It is evident, however, that in the final analysis a decision on their validity can only be arrived at on an arbitrary basis. No amount of technical or scientific data can decide for instance the acceptance of premise one. Yet it must be decided before we can proceed effectively with any scheme for extending the scale beyond 100.

A question has also been raised as to the suitability of the second part of premise number two. This is based on evidence that the reproducibility of the octane number determinations above 100 ON is not as satisfactory as it is immediately below 100 ON and that the use of iso-octane plus lead as reference fuels is a contributory factor. The ASTM group has therefore recommended that work be pushed until sufficient information is available to assess the potentialities of reference fuel systems in this respect.

It is possible that an intensive research program may produce an alternate pair of reference fuels in place of iso-octane and TEL. So far a careful search has not done so. The use of mesitylene has recently been suggested, but much work remains to be done to obtain a source of suitable purity and to check its antiknock value in terms of other fuels before it can be considered. In view of much past work on alternative reference fuels since

1938, it may not be worth while to look further and an arbitrary decision may be needed on this point.

Finally it is evident that the Performance Number scale below 100 fails to meet premise one and if the PN scale were adopted only for numbers above 100 as has been done in the aviation industry, such a scale would fail premise three. The advantage of this scale, however, is that it is in a degree related to engine performance. The antiknock scale extension based on ON = 128 — 2800/PN is continuous at the 100 octane point when plotted against the PN scale and so meets premise three. The curvature of this scale makes each successive octane number above 100 represent a greater and greater amount of antiknock value. This characteristic results in an antiknock rating of 110.6 for iso-octane + 6 ml TEL which is considered by many parties as too low a number for the amount of antiknock value that it represents.

Latest Recommendations—After careful consideration of all the factors involved, the CFR Group adopted with certain modifications a suggestion originally put forward by General Motors Research representatives. Broadly speaking the extension was constructed on a plot of octane numbers versus performance numbers by extending a straight line connecting the 95 and 100 octane points, and using the formula

$$ON = \frac{100 + PN - 100}{3}$$

for extending beyond 100.

$$ON = 100 + \frac{1.0 + 0.736\,TEL - \sqrt{1.0 + 1.472\,TEL - 0.035216\,(TEL)^2}}{0.0204\,TEL}$$

Strictly speaking this scale is not continuous at 100 octane number, but some engine tests indicate that a slope of one-third performance number more nearly approximates unsupercharged engine performance than does the A. N. Performance Number. However, any reference to performance number in the final recommendation was considered objectionable so an equation was derived using the original performance number equation and based on only the TEL in iso-octane units. After much discussion and deliberation the CFR Group recommended that:

1. The present octane number scale be used to define fuel antiknock quality at and below 100.
2. The extension of the octane number scale above 100 be defined in terms of iso-octane and tetraethyllead.
3. The units of measurement above 100 be called octane numbers.
4. Ratings above 100 octane numbers in terms of tetraethyllead and iso-octane can be converted to octane numbers by the following equation using a prepared set of tables or the chart shown in Figure 3.

Present Situation—As previously noted, certain objections have been made by various organizations to these recommendations, most of them being concerned with the acceptance of the four premises on which the recommendations were based. They will be discussed at length by the C.F.R. committee at a meeting to be held on June 6th at Atlantic City. They will also be discussed by ASTM Committee D-2 and its appropriate subdivisions and it is expected that as a result of all these discussions, a set of recommendations acceptable to both industries will be issued by the appropriate committees in the near future.

Original presentation of this manuscript was before the joint meeting of the Automotive Research Committee and Committee on Petroleum Products of API, Montreal, May 16, 1955. # #

ASTM Agrees, One Year to Complete

"IT APPEARS that a decision on the method for extending the octane number scale above 100 octane has been tentatively reached." This statement was issued recently by the officers of ASTM Committee D-2 on Petroleum Products and Lubricants as a result of their deliberations at the Annual Meeting of the American Society for Testing Materials in Atlantic City.

It will take another year to complete the formalities and to publish complete details, but a large majority of Division I on Combustion Characteristics (a subcommittee of ASTM Committee D-2) and Committee D-2 itself, have agreed on the following points:

1. Octane numbers below 100 are defined by mixtures of iso-octane and n-heptane. There will be no revision of the scale below 100.
2. Antiknock values above 100 octane number will be expressed as Octane Number.
3. Reference fuels above 100 Octane Number will consist of Iso-Octane containing up to 6 ml of TEL per gallon.
4. Iso-Octane containing 6.0 ml of TEL per gallon will be defined as 120.3 octane number.
5. These reference fuels will have the same values for both the Motor and Research methods for determination of octane number.

Further description of the reference fuels (iso-octane plus TEL) for use between 100 and 120.3 is expected to be available on request about October 1, 1956. Requests should be addressed to W. T. Gunn, Secretary, ASTM Committee D-2, Room 2040, 50 W. 50th Street, New York 20, N. Y.

Other officers of the Committee are, Chairman, H. M. Smith, U. S. Bureau of Mines, Bartlesville, Okla., Vice-Chairman, R. C. Alden, Phillips Petroleum Company, Bartlesville.

All of the officers agreed that while the decisions reached in Atlantic City were not unanimous, they have the support of a large majority of the producers and consumers of motor fuels. Even those producers and consumers who are not entirely in favor of the decisions that were reached prefer these decisions to further indecision. ##

Use this method for . . .

Fast Butane Analysis

Here is a new adsorption technique for butane analysis. A simple and inexpensive apparatus gives accurate and highly reproducible results.

H. S. Myers and H. G. Hipkin
C F Braun & Company, Alhambra, Calif.

THE PETROLEUM INDUSTRY has long needed a simple, rapid and inexpensive method for analyzing butane-isobutane mixtures. This method utilizes synthetic zeolite crystals for the selective adsorption of butane from the mixture. Analyses are highly reproducible and agree closely with those obtained by other techniques.

Structure of Sieves—Recently a new type of porous zeolite crystal has become available.* The crystals, or sieves as they have been called, are synthetic zeolites composed of calcium, silicon, aluminum, and oxygen. Their crystalline structure contains a large number of small cavities, interconnected by a number of still smaller pores. These cavities and pores are precisely uniform in size, and normally contain water molecules. But when the sieves are heated, this water of hydration is driven off, leaving voids that comprise nearly 50 percent of the total volume of the crystals.

Adsorption—The empty cavities in these porous crystals have a strong tendency to recapture their water of hydration. If no water is present, they will adsorb any material that can get into the cavity. In this manner it is possible for the sieves to separate molecules that are smaller in diameter than the pores, from those that are larger. Several pore-sizes are available. Regeneration of the sieves is accomplished by heating to about 300 to 600 F., and purging with dry air or nitrogen.

BUTANE ANALYSIS

Literature distributed by the manufacturer indicates that these synthetic zeolites with a 5 Angstrom pore-size will adsorb normal butane but not isobutane. This suggested the possibility of using the 5 Angstrom sieves to analyze butane-isobutane mixtures.

Initial Test—The first test was made to determine whether or not butane removal by the sieves is quantitative. This was done by passing a known mixture of gaseous butane-isobutane through a bed of the sieves and into an infrared analyzer. The gas leaving the sieves showed no trace of normal butane, and so it was concluded that the butane removal is quantitative, and that it would be feasible to use the sieves to analyze butane-isobutane mixtures.

Continuous Analyzer—one method of using the sieves might be in a continuous analyzer. The gas mixture would be passed continuously through a bed of the sieves and metered at the inlet and the outlet of the bed. Periodically, of course, the sieves would require regeneration. The chief drawback to this scheme is the difficulty of metering the streams accurately. Wet test-meters might work, but they would require large gas samples in order to get sufficient accuracy. It seemed that for the short-range program, the continuous approach would not be practical. On a long term basis, however, the continuous analyzer might be developed into a highly workable tool.

Orsat Technique—Another technique might be to use the sieves in place of the conventional absorbent solution in an Orsat apparatus. Several types of equipment were tested with butane-isobutane mixtures. But none of the Orsat devices proved to be satisfactory.

Meet the Authors

H. S. MYERS is a research engineer with C F Braun & Company at Alhambra, Calif. With the company since 1952, he previously was with the Petroleum Refining Laboratory at Pennsylvania State University. He was with the laboratory eight years. Dr. Myers received his B.S., M.S. and Ph.D. degrees at Pennsylvania State University.

H. G. HIPKIN has been a research engineer with C F Braun & Company since 1951. Assigned to the company's main offices in Alhambra, Calif., he is in charge of the Research department's Fractionation group. His background also includes five years with Polymer Corporation at Sarnia, Ont. He is a graduate of the University of British Columbia with B.A. and B.A. Sc. degrees, and holds a M.S.E. degree from the University of Michigan and a Sc.D. degree from Massachusetts Institute of Technology.

* Linde Air Products Company.

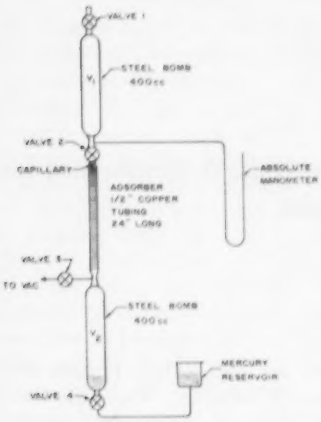


FIGURE 1—Schematic arrangement of apparatus used in this method of analysis.

Pressure Method—Our most promising technique to date consists of expanding the gas sample into an evacuated container of the sieves, and measuring the rise in pressure. Figure 1 is a sketch of the apparatus. The mercury leveling-bulb on the bottom bomb is used to adjust the volume of this bomb so that the total free volume below valve 2 is exactly equal to the volume above valve 2. After each analysis the adsorber is heated to about 300 or 400 degrees, evacuated, and cooled again to room temperature.

Theory, Ideal Case—With certain assumptions, the theory of the pressure method is simple. First let us assume that the volumes above and below valve 2 are equal, and that the vapors are ideal. We must also assume that after the pressures have equalized, there is no diffusion of gases through the capillary attached to valve 2. And finally, the temperatures before and after expansion must be equal. The initial pressure is called P_o, and the final pressure, P_F. The volume above valve 2 is V_1 and the free volume below the valve is V_2. It has already been assumed that these two volumes are equal.

First the entire system is evacuated, and then valve 2 is closed. Next, V_1 is filled to a pressure of P_o with the unknown gas-mixture. The number of moles of gas in V_1 can be represented by P_oV_1/RT or P_oV_1k, since T has been assumed constant.

After valve 2 is opened and the pressures have equalized, the moles of gas remaining in V_1 are P_FV_1k. This means that the total moles leaving V_1 and passing into the adsorber are

$$N_L = P_oV_1k - P_FV_1k \qquad (1)$$

The number of moles of unadsorbed gas remaining in the entire system after adsorption are

$$N_F = P_F(V_1 + V_2)k \qquad (2)$$

Or, since V_1 has been assumed equal to V_2

$$N_F = P_F(2V_1)k \qquad (3)$$

The moles adsorbed can then be represented as

$$N_A = P_oV_1k - 2P_FV_1k \qquad (4)$$

Dividing the moles adsorbed by the total moles leaving V_1 gives the mole fraction adsorbed, ϕ

$$\Phi = \frac{P_oV_1k - 2P_FV_1k}{P_oV_1k - P_FV_1k} \qquad (5)$$

or

$$\Phi = \frac{P_o - 2P_F}{P_o - P_F} \qquad (6)$$

This is the working equation for the ideal case, since for butane-isobutane mixtures the mole fraction adsorbed is equal to the mole fraction of butane in the sample.

Calibration—In order for Equation 6 to be valid, the net free volume below valve 2 must be exactly equal to the volume above valve 2. If we assume that isobutane is completely unadsorbed by the sieves, a simple procedure can be used to equalize the volumes.

First, the entire apparatus is evacuated to an absolute pressure of less than 1 mm Hg. Then valve 2 is closed, and pure isobutane is added to the upper chamber through valve 1 until the pressure reaches an arbitrary value of 800 mm Hg absolute.

Next, the vacuum pump is valved off by closing valve 3, and the isobutane is allowed to expand into the lower chamber by opening valve 2. During this time, valve 4, the valve to the mercury reservoir, is kept closed. If there is no adsorption, and if the free volume below valve 2 is equal to the volume above valve 2, the pressure will be halved when valve 2 is opened. And so, after the pressures have equalized, valve 4 is opened, and mercury is added to the lower chamber until the pressure of the system rises to 400 mm Hg. Then valve 4 is closed, and the mercury reservoir is no longer needed until the sieves are replaced.

Limitations—As has been previously mentioned, Equation 6, when used with the above calibration procedure, is valid if there is no isobutane adsorption on the sieves. It is also valid if the sieves do absorb some isobutane, so long as the adsorption is a linear function of pressure. Suppose, for example, there is a slight surface-adsorption of isobutane on the sieves, or on the walls of the vessel. Further, let us assume that this adsorption is a linear function of pressure. That is, using our earlier terminology, the adsorption is equal to P_FK. For a given apparatus with a definite weight of sieves, K can be

TABLE 1—Butane Analyses by Molecular Sieves Compared With Other Methods

SAMPLE	MOLE PERCENT NORMAL BUTANE				
	Synthetic Zeolite Crystals		Infrared		Low Temperature Fractionation
	Ideal	Corrected	Lab 1	Lab 2	
1	34.6 34.6	34.2 34.2	31.8	33.3	34.15
2	44.7 44.5	44.2 44.0	42.3	43.8	44.39
3	60.7 60.6	59.8 59.7	58.0	58.7	60.04
4	75.2 75.0	74.0 73.8	73.4	73.3	74.05
5	82.2 82.3	80.7 80.8	80.0	80.2	81.6
S-32[1]	77.1[2]	75.8[2]	(76.0 Butane + Propane[1])		

[1] This was a standard sample supplied by Phillips Petroleum Company, and made up by weight. It had a specified composition of 24.0 percent isobutane, 73.0 percent n-butane, and 3.0 percent propane. The sieves absorb both the n-butane, and the propane.
[2] N-butane plus propane.

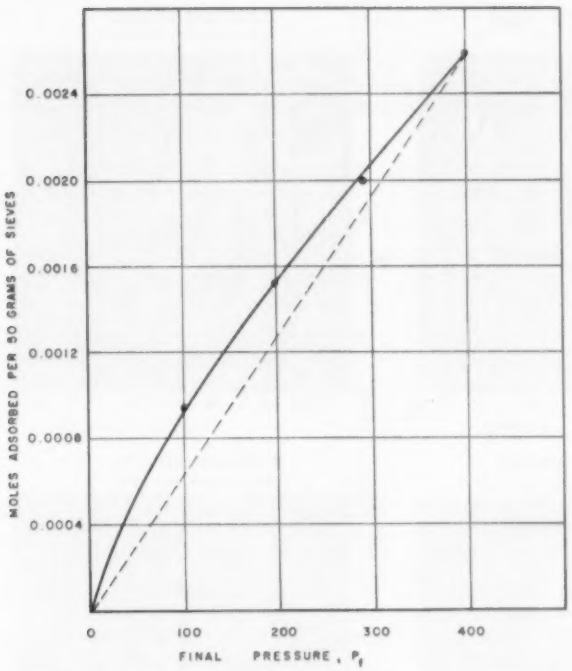


FIGURE 2—Surface adsorption of isobutane on zeolite sieve crystals

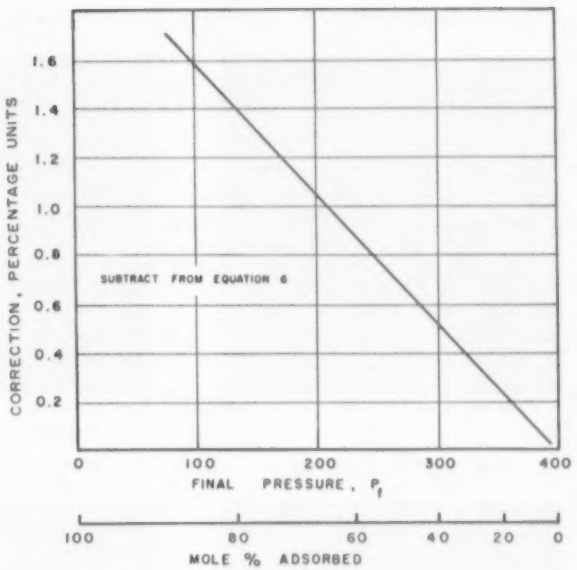


FIGURE 3—Correction factor for surface adsorption to be subtracted from Equation 6.

considered as a volume, V_A, the volume of butane that is adsorbed per unit of pressure. Equation 2 can now be written as

$$N_F = P_F (V_1 + V_2 + V_A) k \quad (2A)$$

But, the calibration procedure automatically sets V_1 equal to $V_2 + V_A$, and so Equation 2A reduces to Equation 3.

Experimental Results—Five butane-isobutane samples were made up in gallon bombs and analyzed by the pressure method just described. Then these same samples were analyzed by infrared at two independent laboratories, and also by low-temperature fractionation. In addition, a standard sample purchased from Phillips Chemical Company was analyzed. Results are shown in Table 1. The values titled ideal were calculated by means of Equation 6.

Duplicate analyses were made on each sample, and were found to be highly reproducible. Calculated percentages of butane appear to be slightly too high—up to about one percentage unit higher than the corresponding low-temperature fractionation analyses.

Correction—For most purposes, the analyses computed from the idealized Equation 6, are probably sufficiently accurate. But since the amount of adsorption seemed slightly high, an attempt was made to find the reason for this discrepancy.

It was suspected that the trouble was caused by surface adsorption of isobutane on the sieves. As was mentioned earlier, this would not cause any trouble if the adsorption were linear with pressure.

The manufacturer of the sieves was able to supply us with one point showing the magniture of this surface adsorption. His data indicate that the sieves surface-adsorb about 0.3 weight percent at a partial pressure of 400 mm Hg. Using this value and a simple experiment, we were able to work up a rough surface-adsorption isotherm for pure isobutane.

The apparatus was calibrated with pure isobutane in the normal manner, starting with a pressure of 800 mm Hg and adjusting the mercury to 400 mm after expansion. Fifty grams of sieves were used in the adsorber. This meant that (50) (0.003) = 0.15 grams or 0.0026 moles of isobutane were surface adsorbed. The initial volume, V_1, was 400 cc, equivalent to 0.0188 moles. Since 0.0026 moles were adsorbed on the sieves, N_2 equals 0.0188 —0.0026 or 0.0162 moles. Substituting in the equation

$$\frac{P_1 V_1}{N_1} = \frac{P_2 (V_2 + V_1)}{N_2} \quad (7)$$

we find $V_2 = 290$ cc.

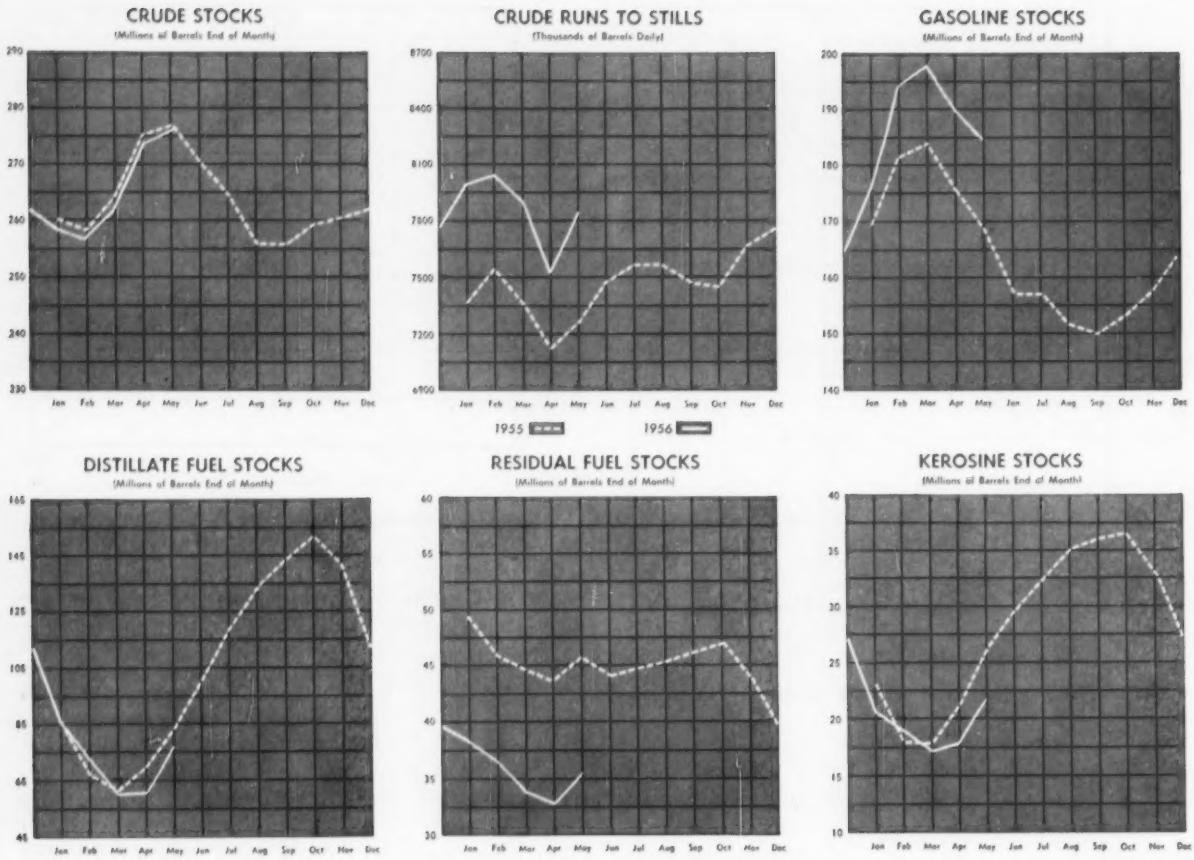
Now the experiment was repeated without changing the mercury level, but at different initial pressures.

Initial Pressure, P_1	Final Pressure, P_2
598	297
398	192
199	91.8

Since V_1 and V_2 are known, values of P_1 and P_2 can be substituted into Equation 7 for each run, and N_2 can be calculated. The difference between N_1 and N_2 equals the moles of isobutane adsorbed at pressure P_2.

The resulting surface-adsorption isotherm is shown in Figure 2. The deviation of this curve from the straight dotted-line of Figure 2, is a measure of the correction that should be applied to adsorption values calculated from Equation 6. This correction has been worked up in a plot as shown in Figure 3.

Referring again to Table 1, we see that this correction brings the sieve analyses, for the most part, closely in line with the low temperature fractionation analyses. # #



Taking Stock

Cecil W. Smith
Economics Editor

- Gasoline output on the rise
- Crude imports at near peak
- Gasoline stocks holding high

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1954:													
May	6,471	7,038	282,250	3,482	177,606	302	23,892	1,372	73,581	1,148	47,009	708	1,021
June	6,500	6,947	285,155	3,483	165,404	306	28,184	1,399	86,325	1,123	50,216	624	999
July	6,242	6,916	284,894	3,480	158,010	295	31,953	1,416	101,657	1,089	54,365	724	1,038
August	6,168	6,862	281,043	3,492	153,168	302	34,949	1,453	117,579	1,069	56,332	664	966
September	6,151	6,939	274,608	3,511	150,916	301	37,099	1,514	128,061	1,086	56,702	672	999
October	6,135	6,834	269,442	3,457	149,661	310	37,140	1,545	139,128	1,066	56,541	642	1,065
November	6,346	6,975	264,566	3,530	150,604	354	34,547	1,622	133,886	1,120	54,891	636	1,104
December	6,394	7,238	258,385	3,605	155,400	381	27,826	1,668	108,144	1,187	52,105	729	1,301
1955:													
January	6,761	7,379	260,156	3,639	169,562	409	23,266	1,740	86,692	1,235	49,457	739	1,348
February	6,835	7,549	258,630	3,655	181,643	374	18,291	1,847	68,513	1,239	46,042	751	1,379
March	6,886	7,374	264,430	3,543	183,972	357	18,187	1,703	62,457	1,185	44,970	742	1,319
April	6,887	7,136	275,232	3,502	175,601	312	21,486	1,534	70,139	1,110	43,838	697	1,123
May	6,677	7,281	276,948	3,605	168,751	296	26,375	1,519	83,559	1,111	45,083	742	1,137
June	6,613	7,484	270,850	3,725	157,439	269	29,830	1,628	100,652	1,080	44,398	764	1,159
July	6,632	7,580	264,601	3,824	157,079	286	32,749	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	290	35,292	1,621	133,675	1,090	45,480	756	1,155
September	6,731	7,483	256,269	3,784	150,194	279	36,361	1,621	143,248	1,061	46,267	829	1,218
October	6,837	7,465	267,346	3,827	153,103	309	36,705	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	341	33,283	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	395	26,770	1,765	111,333	1,286	39,174	884	1,502
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	385	18,712	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	342	17,215	1,808	60,846	1,213	32,984	934	1,425
April	7,144	7,501	274,030	3,581	189,770	310	18,090	1,720	62,810	1,139	32,790	829	1,252
May	7,057	7,865	276,390	3,715	184,676	293	21,710	1,705	76,632	1,174	35,686	919	1,337
Week Ended:													
6-15-56	7,066	7,953	274,075	3,909	181,487	291	23,793	1,721	84,996	1,080	37,319	786	1,198
6-17-55	6,626	7,520	275,768	3,648	165,285	314	28,435	1,601	91,269	1,158	45,684	817	1,196

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

Make Petrochemicals From Air and LPG

Discussed here are the effects of hydrocarbon feed stocks, oxygen ratio, pressure, and temperature when producing oxygenated chemicals.

R. L. Mitchell
Celanese Corporation of America
Clarkwood, Texas

OXIDATION HAS been the most important unit process since man built his first fire. It has long been used as a source of power. However, it is only with the advent of the internal combustion engine and the discovery of petroleum that its uses have expanded to where it is one of the most versatile unit processes, particularly for the production of chemicals.

Bone and his associates working in England at the turn of the century might be considered the first serious scientific experimentalists in the field of hydrocarbon oxidation.[1,2] During the ensuing 50 years, the techniques for the oxidation of low molecular weight hydrocarbons have been developed to the point where oxidation is a major basic process. Concurrently there has been considerable effort expended in both academic and industrial research laboratories in an attempt to elucidate the reaction mechanisms. It is interesting that in this field, commercial application has greatly preceded the knowledge of exactly what is going on. It has been sufficient to know what will be obtained under given sets of conditions and then to proceed empirically to commercial scale.

Celanese first became interested in the production of chemicals via hydrocarbon oxidation in the mid-thirties. This interest was occasioned by a desire for a dependable source of raw material for the production of cellulose acetate. Of particular interest was the production of acetic acid and acetone, the first being used in acetylation and the latter as a spinning solvent. As a step toward this vertical integration, a group of chemists and chemical engineers, some of whom were experienced in hydrocarbon oxidation, started work at the Cumberland, Maryland, plant in 1934. Within five years a pilot plant was in operation producing one ton per day of acetaldehyde from liquefied petroleum gases as feed material. Three years later a second pilot plant producing ten tons of acetaldehyde per day was running. This last unit furnished the basis of design for the commercial plant at Bishop, Texas.

At this point, World War II had begun, and construction materials were on allocation. Since the basic oxidation process produced large quantities of acetaldehyde, approval was granted for construction at Bishop of a defense plant for the production of butadiene via aldoling of the acetaldehyde, hydrogenation, and subsequent dehydration of the resulting 1,3-butylene glycol. This had also been studied at Cumberland on a pilot plant scale. Simultaneously with construction of the Chemcel plant at Bishop, all chemical research was transferred from the Amcelle plant at Cumberland to its present location at Clarkwood just outside of Corpus Christi. Celanese, among many others in the industry, has continued to study the oxidation process with a view toward improving existing processes and developing new techniques of oxidation.

Oxidation of propane and butanes has probably received more intensive study than oxidation of the other low molecular weight hydrocarbons. This, at least in part, has been due to the greater availability coupled with ease of oxidation. An important deterrent to the oxidation of higher molecular weight hydrocarbons is the complexity of the products obtained. For example, oxidation of propane would be expected to give propionaldehyde, propanols, acetone, propylene oxides, propionic acid, acetaldehyde, ethanol, ethylene oxide, acetic acid, formaldehyde, methanol, formic acid, carbon monoxide, and carbon dioxide. This is a total of 16 oxygenated products exclusive of secondary products.

For comparison oxidation of as simple a compound as n-hexane could result in approximately 60 basic products including unsaturated oxygenated compounds and those secondary products such as esters, formals, and acetals formed by reactions between basic products. It can be easily seen that the latter complex mixture almost defies analysis and separation.

Coupled with the above disadvantages is the fact that the higher molecular weight hydrocarbons cannot be obtained in large commercial quantities as pure compounds but are usually present as mixtures. Consequently, until better analytical and industrial separation methods become available, it is believed that most commercial oxidation of hydrocarbons will be limited to the lower molecular weight members of the series.

The reaction mechanism for the non-catalytic vapor-phase oxidation of hydrocarbons is free radical in nature and believed to be of this type:

1. $RH + O_2 \rightarrow R + HO_2$
2. $R + O_2 \rightarrow RO_2$
3. $RO_2 + RH \rightarrow RO_2H + R$
4. $RO_2 \rightarrow$ products
5. $RO_2H \rightarrow$ products

There is a difference of opinion as to whether or not products are formed directly from the peroxy radical as in 4 or whether it is necessary to form the discreet hydroperoxide first as in

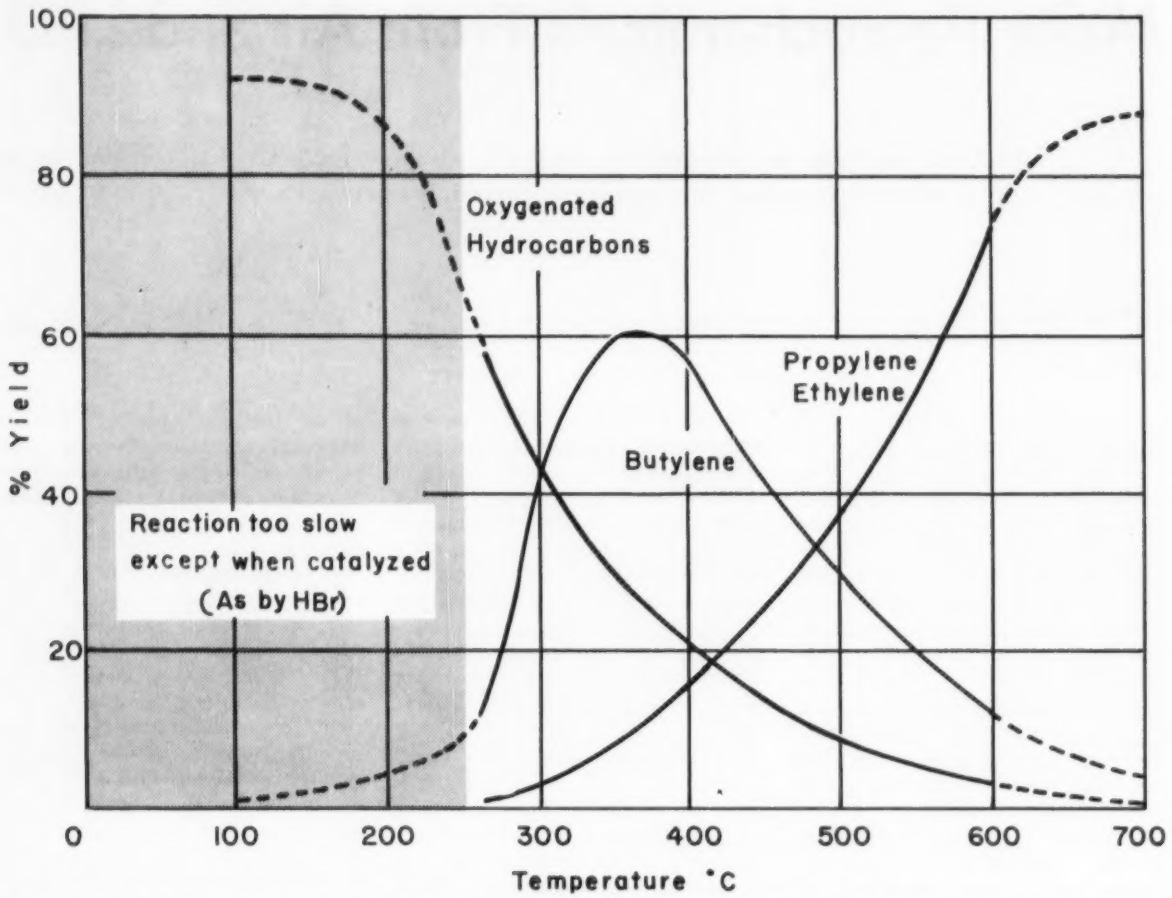


FIGURE 1—Effect of temperature on the distribution of products when oxidizing butane with air at atmospheric pressure and constant reactant ratio.

5. From a practical standpoint it makes little difference in predicting the products to be obtained. The over-all reaction is characterized by an induction period. It can be readily seen that the type of carbon-hydrogen bond involved in the reaction drastically affects the products obtained. The relative reaction rates for carbon-hydrogen bonds at 300 C are approximately 1:2:10 for primary, secondary, and tertiary, respectively.[3] Thus, it would be anticipated that propane and n-btuane, for example, with secondary hydrogens would be much more reactive than methane and ethane with only primary hydrogens. That this is the case has been shown by Newitt.[4]

An examination of Table 1 will show that at 50 atmospheres propane and butane start oxidation at 248 to 255 C. However, ethane requires 276 C. and methane with four primary hydrogens requires a temperature of 350 C. The temperatures are somewhat lower as the pressures are increased, but the relative ease of oxidation remains in the order of butane, propane, ethane, followed by methane.

Changing hydrocarbon feed stocks causes large changes in product distribution. It would be anticipated that products from isobutane would be characterized by history of oxygen attack upon the tertiary hydrogen since the tertiary hydrogen-carbon bond is the weakest. This is true as evidenced by the high yields of acetone obtained from isobutane. Also as predicted, oxidation of propane and butane gives more products characterized by oxidative attack upon secondary hydrogens than products which would originate by attack upon primary hydrogens. In this manner it has been possible to predict partially the product distributions to be expected when oxidizing any of the lower molecular weight hydrocarbons.

TABLE 1

Hydrocarbon	Temperature, C., at Which Oxidation is First Detectable When the Pressure is			
	1 atm	50 atm	100 atm	150 atm
Methane	420	350	330	320
Ethane	285	276	260	
Propane	270	255	245	232
Butane	.....	248	220	210

The variability in product distribution which can be obtained by changing feed is shown in Table 2.

It will be noted that acetone is produced in much greater quantities from isobutane than from either propane or n-butane. Also, it will be noted

that the production of acetaldehyde and methanol from isobutane is less than from either of the other two. This would indicate a choice of isobutane as a feed if it were desired to produce acetone and either propane or n-butane if acetaldehyde or methanol production were the major requirement.

Even more startling is the variation in oxide yield when an alkane is compared with its corresponding olefin as shown in Table 3.

Striking differences are found in 1,2-propylene oxide yields when comparing propane and propylene. Propylene gives almost six times the yield obtained from propane. Likewise, a comparison of normal butane with the normal butylenes shows increased quantities of the 1,2- and 2,3-butylene oxides from the olefins.

The ratio of hydrocarbon to oxygen is a very important variable to be considered in studying the vapor-phase non-catalytic oxidation of hydrocarbons. Of course, there are practical limits to commercial variation of the hydrocarbon to oxygen ratio. It is usually desirable to operate below the lower explosive limit since under these conditions in a flow system, the reaction temperature may be maintained within reasonable limits. It is not economically feasible to operate with too high a ratio since under these conditions the conversion per pass may become so low as to make equipment prohibitively large.

Under isothermal conditions in a static system, Newitt has shown that as the hydrocarbon to oxygen ratio is increased, the conversion to all condensable products increases while that to degradation gaseous products decreases.[4]

It will be noted from Table 4 that at a hydrocarbon to oxygen ratio corresponding to a hydrocarbon to air ratio of 1:20, only 47.6 percent of the carbon is found in desirable products while 52.4 percent ends up as carbon oxides. When the hydrocarbon to oxygen ratio is increased to 2:1, 85.5 percent of the carbon appears as desirable compounds and only 15 percent goes to degradation products. Under isothermal conditions an increase in the hydrocarbon to oxygen ratio results primarily in the increased yields of alcohol, whereas other products are essentially unchanged.

In a flow system it is more difficult to maintain isothermal conditions. Data have been obtained under adiabatic conditions, however. In this case it will be noted that an increased hydrocarbon to oxygen ratio results in increased yields of other desirable products as well as alcohol when propane is used as feed. These increases are accompanied by a significant decrease in the undesirable degradation products, carbon dioxide, and carbon monoxide. (See Table 5.)

Not only are there increases in the formation of desirable products, but to a great extent these compounds are characterized by a higher molecular weight occasioned by less degradation of the carbon skeleton of the parent feed.

The effect of pressure upon product distribution is very marked, particularly in the range between atmospheric pressure and 100 psig. When n-butane is oxidized under conditions of constant temperature and constant hydrocarbon to oxygen ratio in a single-pass flow system, there is little change in distribution of oxygenated products at 100 pounds per square inch gage as compared with atmospheric pressure operation. The yield, however, defined as pounds of product per gallon of butane reacted, is only half as great under the latter conditions as at 100 psig. The other half of the butane reacted or converted appears as butylenes. This fact has also been reported by Newitt.[4]

The effect of temperature is even more pronounced than that of pressure. Figure 1 shows the effect of the reaction temperature upon the yield of products from the oxidation of n-butane at atmospheric pressure and at a constant ratio of butane to air.

Three types of products are de-

TABLE 2
Effect of Alkane Feed

Products	Liquid Product Distribution, Weight Percent		
	Propane	n-Butane	Isobutane
Acetaldehyde	28.0	30.6	17.0
Formaldehyde	26.4	22.9	19.8
Methanol	23.8	19.4	13.8
Acetone	1.7	4.9	26.0
Three Carbon Aldehydes	2.9	4.5	3.8
Propylene Oxide	2.5	....	3.0
Butylene Oxides	....	2.8	1.1

TABLE 3—Effect of Olefin Feed

Product	Yield, Moles per 100 Moles of Hydrocarbon Oxidized				
	Propane	Propylene	n-Butane	Butene-1	Butene-2
1,2-Propylene Oxide	2	11.5	....	....	....
1,2-Butylene Oxide	....	....	1	8	....
2,3-Butylene Oxide	....	....	1.5	....	6.8

TABLE 4—Effect of Reactant Ratios
(Products from the oxidation of propane at various propane-to-air ratios.)
Temperature—275 C.

Propane-to-Air Ratio	1:20	1:15	1:3.6	1:1.25	1:0.5
Products	Yield, Percent of Carbon Propane Oxidized				
Total Aldehydes	12.5	8.8	12.0	16.1	16.7
Normal Alcohols	17.3	25.5	23.0	33.1	34.5
Isopropyl Alcohol	2.7	6.9	5.2	5.2	14.4
Acetone	1.2	1.4	1.3	0.3	7.4
Acids	13.9	13.4	15.2	8.9	12.5
Total Condensable Products	47.6	56.0	56.7	63.6	85.5
Carbon Dioxide	31.5	25.0	22.1	10.5	7.0
Carbon Monoxide	20.9	19.0	21.3	25.9	8.0

TABLE 5
Effect of Reactant Ratios
(Adiabatic flow system, propane feed)

Propane-to-Oxygen Ratio	4.5	9.4	18.0
Products	Product Distribution, Weight Percent		
Carbonyls	33.0	45.7	51.0
Alcohols	15.1	21.1	24.7
Carbon Oxides	37.2	20.8	13.3

TABLE 6
Effect of Pressure
[Products from the oxidation of propane at several pressures (Propane-to-Air ratio of 1 to 3.6)]

Pressure in Atmospheres	1	20	60	100
Reaction Temperature, C.	373	281	252	250
Products	Yield, Percent of Carbon from Propane Oxidized			
Total Aldehydes	20.5	21.8	13.5	13.7
Normal Alcohols	19.7	21.0	17.5	15.2
Isopropyl Alcohol	1.3	2.8	6.2	16.0
Acetone	0.5	4.3	12.5	7.9
Acids	4.3	17.0	19.0	18.9
Total Condensable Products	46.3	66.9	68.7	71.7
Carbon Dioxide	7.3	17.1	21.4	20.6
Carbon Monoxide	21.3	16.0	9.9	7.7
Propylene	25.1	....	....	....

picted: (1) oxygenated products, (2) olefins characterized by maintenance of the carbon skeleton, and (3) olefins characterized by degradation of the carbon skeleton. All three types occur at a given temperature, with each building to a maximum. The highest yield of oxygenated compounds occurs near 100 C. The highest yield of butylene occurs at 375 C. and that of propylene and ethylene between 700 and 800 C. If this graph were extended to higher temperatures in excess of 1000 C., a fourth curve for acetylene products would result. Below 230 C. the reaction rate is so low as to make a catalyst necessary for a commercially practical process. The effect of higher pressure would be to shift all three curves to the right. Thus the peak yield for butylenes at 100 psig would be about 600 C. instead of the 375 C. shown for 15 psia.

All the above discussion is limited to vapor-phase oxidation. Celanese Corporation of America has for ten years been oxidizing propane and butane in its Bishop, Texas, plant by a non-catalytic vapor-phase oxidation technique. This involves passing a mixture of hydrocarbons and air in the desired proportions through a pre-heating furnace to bring the gases to reaction temperature. Thence, the gases pass through a reaction chamber wherein reaction takes place. The reacted mixture is passed through a tower where oxygenated products are condensed and scrubbed out with water.

The butane and non-condensables including carbon oxides, nitrogen, hydrogen, and methane are recycled to the reaction furnace. Fresh makeup hydrocarbon and air are added to this recycle stream. Prior to this addition, a sidestream is taken off for removal of non-condensables equivalent to the nitrogen in the added air. In this unit, butane and propane are separated from the non-condensables and recycled to the furnace; the non-condensables are vented. This technique allows an ultimate conversion of 100 percent of the hydrocarbon feed.

This reaction is termed "shotgun" because it produces a relatively large number of compounds. At present the following compounds, representing over 90 percent of the total production, are recovered and purified in the Chemical plant; methanol, propanol, isobutanol, butanol, formaldehyde, acetaldehyde, acetone, methyl ethyl ketone, mixtures of C_4 — C_7 ketones, a mixture of C_5 — C_7 alcohols, and propylene and butylene oxides.

Celanese has developed a catalytic liquid phase oxidation technique which is now employed in its Pampa, Texas, plant. In this plant, butane is oxidized in a solvent. Air is bubbled through this solvent, and the unreacted nitrogen passing overhead from the liquid carries with it proportionate amounts of butane and formic, acetic and propionic acid, methyl ethyl ketone, acetone, methanol, etc. The quantities of each carried overhead in the gas stream are determined by their partial pressures. The overhead gases are condensed, the products removed, and the nitrogen and other non-condensables are vented to the atmosphere.

Products are sent to purification towers, and the butane is recycled to the reactor together with fresh butane feed and more air. This technique produces acetic acid predominantly from n-butane under the conditions described. However, the reaction conditions can be varied to produce increasing quantities of methyl ethyl ketone instead of acetic acid. Likewise, isobutane produces acetone and methanol and smaller quantities of tertiary butyl alcohol. Propane will produce acetone, or by altering the conditions of oxidation, can be made to produce acetic acid.

With a continuing increase in prices which must be paid for petroleum products, it will be necessary for users of the vapor phase oxidation process to continue research being performed to increase the over-all yield of saleable oxygenated products from the hydrocarbon converted. An offshoot from this will be utilization of methane and ethane as feed since these are the other two most plentiful pure hydrocarbons available today. Because of the high temperatures required for non-catalytic oxidation, it is probable that catalysts must be employed to protect the compounds formed from the effects of excessive temperature.

There will be a trend toward processes which are much more selective. This is exemplified by the Celanese process used at Pampa to produce predominantly acetic acid. Another trend will be toward utilization of feed stocks which are not of petroleum origin. This is demonstrated by processes used for production of vanillin from lignin and azelaic acid from agricultural oils.

This latter movement will become increasingly important as price advances occur in petroleum and its byproducts. It has been accelerated in recent years by movement of greater quantities of petroleum products through transcontinental pipe lines. These price increases also have had an effect on the necessity for continually improving hydrocarbon efficiencies of existing processes. However, since carbon is one of the more plentiful elements, it is believed that its oxidation will continue to be an important means of producing chemicals.

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Meet the Author

ROBERT L. MITCHELL is director of engineering research for Celanese Corporation of America at its Clarkwood, Texas, plant. With the company since 1947, most of Mitchell's experience has been in the operation of pilot plants on hydrocarbon oxidation. In his present assignment, he is in charge of pilot-plant work at Clarkwood and the economic evaluation of research. Mitchell was graduated from Texas A&I College in 1943 with a B.S. degree in chemical engineering. After more than three years as a radar-maintenance officer in the Navy, he entered Massachusetts Institute of Technology where he completed his master's degree in chemical engineering in 1947.

How to Stop Corrosion in Sulfur Plants

In three plants, Stanolind has found that redesigning and insulating equipment will prevent the cause of corrosion—condensation in process lines.

J. W. Kilmer, M. H. Rahmes and H. L. Lawler
Stanolind Oil & Gas Company, Tulsa

STANOLIND HAS found ways to prevent corrosion in three sulfur recovery plants that experienced major corrosion. The principal cause of the corrosion was solution of corrosive gases in moisture condensed from the process streams.

Sulfur recovery plants operate at 5 pounds per square inch gage or less. Flame temperatures in the boiler or combustion chamber are in the order of 1800 F. to 2300 F. Reactor inlet temperatures range from 400 to 500 F. and reactor outlet temperatures may be as high as about 800 F. Reactor effluent streams are usually cooled to about 300 F. for condensation of sulfur vapor. Besides hydrogen sulfide, sulfur dioxide, sulfur vapor and water the various process streams usually contain considerable nitrogen and carbon dioxide, and may contain small quantities of carbonyl sulfide, carbon disulfide, oxygen and hydrocarbons.

PLANT A

In this plant (Figures 1 and 2) one-third of the inlet stream was originally burned in a vertical water tube boiler. The effluent products of combustion were mixed with the remaining two-thirds of the plant inlet stream and passed to a reactor containing catalyst. From the reactor the stream passed through a condenser where it was cooled with resultant condensation of sulfur and attendant generation of 35# steam. The remaining gas was then reheated by means of an in-line burner and then passed to a second reactor and second condenser-separator. Waste gases were then disposed of in a stack.

The product sulfur flowed by gravity to an underground pit containing steam coils and was pumped from this pit to solid storage.

Shortly after startup serious corrosion was encountered in the combustion boiler. Products of combustion penetrated openings in the refractory lining of the furnace and condensed on the cool steel shell. Similar condensation and attendant corrosion

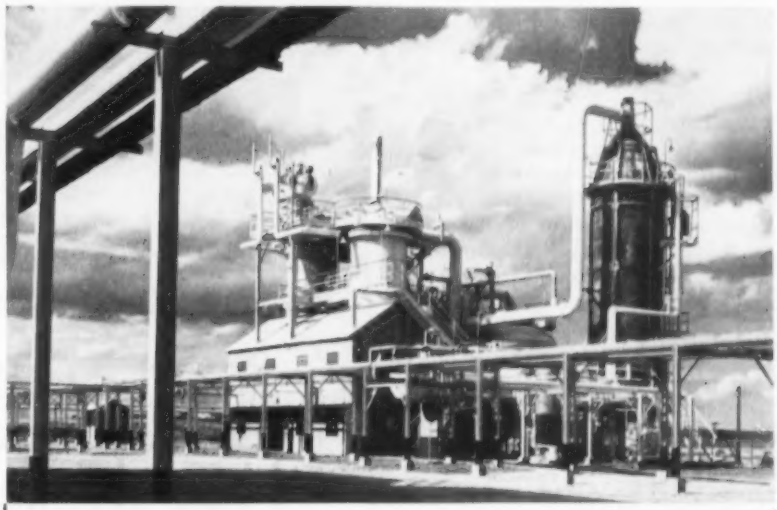

FIGURE 1—Additional corrosion at this plant included failure of overhead line from the boiler.

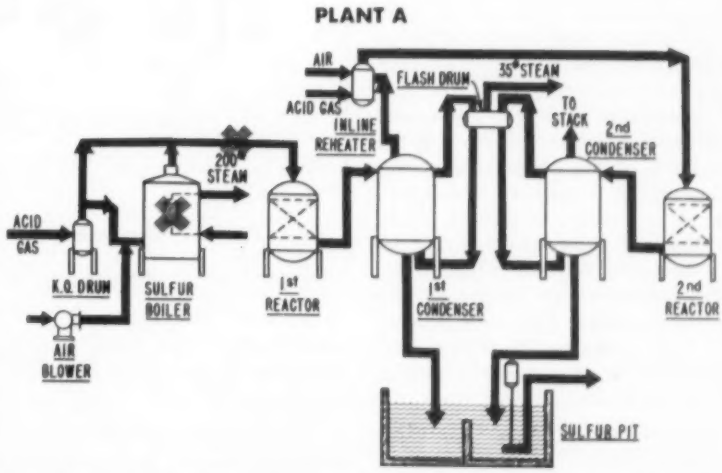

FIGURE 2—After one year's operation, vertical water tube boiler had to be replaced with horizontal marine boiler.

occurred in the plenum chamber beneath the burners. After one year's operation it was necessary to replace the entire outer shell of the boiler and redesign the plenum chamber. Further corrosion of the stainless steel radiant cone at the combustion zone of the boiler, failure of the lead rupture disk at the top of the furnace, pilot and main burner failures due to corrosion, all led to eventual replacement of the vertical water tube boiler with a horizontal marine type boiler. It is believed that failure of the radiant cone may have been due to sulfiding. Failure of the lead rupture disk has been attributed indirectly to bimetallic cell action. Actual corrosion damage occurred to the stainless steel retaining flanges which in turn caused mechanical failure of the lead disk. Corrosion of the pilot and main burners may have been due, at least in part, to condensed water particularly during shutdowns. Additional corrosion encountered at this plant included failure of the overhead line from the boiler downstream of the point where the combustion products join the acid gas bypass line.

The plant has stainless steel catalyst supports and screens, stainless steel piping from the reactor outlets to condenser separators, and refractory lining in the reactors. Otherwise, bare carbon steel is used throughout.

FIGURE 3—Minor corrosion occurred in the steel cover plates of the sulfur pit.

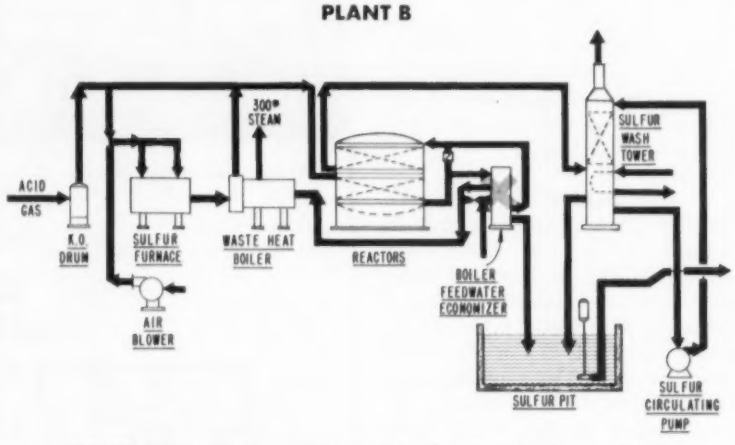

FIGURE 4—Corrosion in economizer was due to failure of refractory lining.

PLANT B

At Plant B (Figures 3 and 4) one-third of the inlet stream together with sufficient air is burned in a reactor furnace from which the combustion gases pass to a waste heat boiler where they are cooled and 300# steam is produced. The cooled combustion gases are mixed with the remainder of the plant inlet stream and passed to a reactor where a portion of the sulfur is formed. From this reactor a portion of the gases pass through a boiler feedwater economizer where sulfur condenses and the gas is cooled. The remainder of the effluent gas from the first reactor is bypassed to control inlet temperature to the second reactor.

From the second reactor, the gases flow to a sulfur wash tower where the sulfur is removed and the waste products pass to a stack for disposal to the atmosphere. Heat removal in the wash tower is accomplished by liquid sulfur reflux which is cooled by a water coil in the base of the wash tower. All sulfur collected drains by gravity into a sulfur pit. From this pit sulfur may be transferred to either liquid sulfur loading facilities or to solid storage.

Minor corrosion has been encountered on the steel sulfur pit cover plates. This has been attributed to solution of corrosive gases in moisture condensed on the cold surfaces. Additional corrosion has been encountered in the economizer, apparently due to failure of the refractory lining and

resultant condensation of moisture on the carbon steel shell.

The loading line for sulfur tank cars is steam jacketed to a point near the cars. At the point where the steam jacket ends several failures of the internal line have been encountered. Carbon steel and Type 304 stainless steel have both failed, and Alloy 20 has recently been installed in an effort to solve the problem. It has been postulated that the failure was due to the presence of wet sulfur dioxide gas formed by entry of air into the loading line when the sulfur in that line drains back to the pit between loading operations.

The combustion chamber, the effluent line to the waste heat boiler, the first stage reactor, and the economizer are lined with refractory. In addition, the catalyst supports are made of cast iron and the catalyst screen and one butterfly valve are stainless steel. With these exceptions the entire plant is constructed of carbon steel.

PLANT C

This is a "straight through" plant, (Figures 5 and 6) that is, acid gas flows through an inlet scrubber at the sulfur recovery plant and then the entire stream passes into the boiler, together with sufficient air to burn one-third of the hydrogen sulfide. The products of combustion are passed to the first reactor and then through a second waste heat boiler where additional steam is generated and the major portion of the sulfur is condensed. The effluent gas stream is then reheated and passed through a second reactor where additional sulfur is formed. Final cooling is accomplished by water injection into the gas stream. The water injection nozzle is located on the center line of the gas inlet nozzle and the water sprays in the direction of gas flow. Liquid sulfur reflux is supplied from the storage pit solely as a wash to scrub droplets of liquid sulfur from the gas stream. Product sulfur from the pit is pumped to either liquid shipping facilities or solid storage.

Corrosion was found in the wash tower when a hole in the shell appeared at a point directly opposite the inlet nozzle. This seems to indicate that complete vaporization of the water injected is not obtained continuously and that the remaining free water is responsible for the corrosion. A shell and tube water cooler is being installed to permit cooling by means of the reflux stream. When this installation is complete, water injection will cease. External corrosion of the steam coils in the vapor space above the sulfur in the storage pit has also occurred. Plans to keep a slow flow of steam through these coils will reduce and possibly stop the attack.

The main flow lines in this plant are cement lined and the reactors are lined with refractory. The catalyst retaining screens are stainless steel. With these exceptions the plant is entirely constructed of carbon steel.

Examination of the conditions leading to most of the corrosion reported reveals that condensation of moisture took place. Considerable water is formed in the reactions occurring in sulfur plants and water dew points of most process streams are in the order of 140 F. Solution of the problem may take two courses. The first is redesign of equipment so that con-

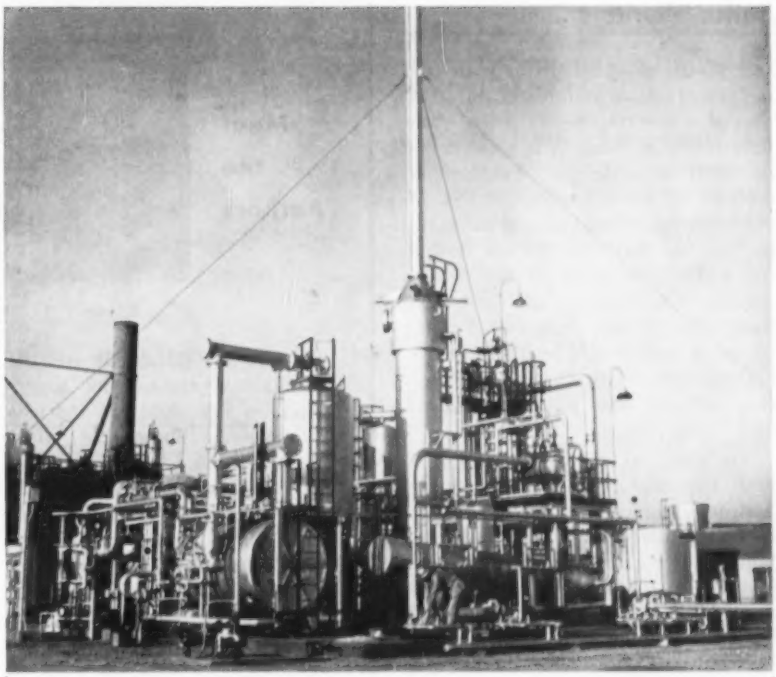

FIGURE 5—External corrosion of steam coils in vapor space above storage pit has occurred here.

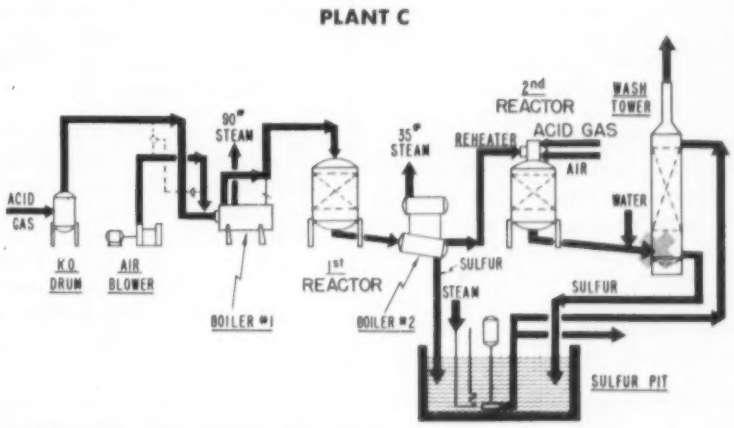

FIGURE 6—Corrosion at the wash tower inlet nozzle will be mitigated by using a shell and tube water cooler instead of water injection.

tact of the process stream with cold metal surfaces is minimized. Substitution of a fire tube boiler for a water tube boiler at Plant A is an example of such a redesign. The second method of corrosion mitigation involves external insulation of the metal surfaces so that they do not cool to the water dew point of the process stream. Observation of these two basic ideas in the design of a sulfur recovery unit should result in an operating unit relatively free of corrosion without the use of expensive alloy construction.

To date no major indication of high temperature attack of steel by hydrogen sulfide has been found in the three plants other than the possibility in the case of the radiant cone in Plant A. However, the areas which should be most susceptible to such attack, e.g., the outlet side of the reactors, are protected by refractory lining.

In preparing this article the authors have had the benefit of material submitted by a number of individuals in Stanolind Oil and Gas Company who are connected with the design and operation of sulfur recovery units. The authors wish to express their appreciation to the management of Stanolind Oil and Gas Company for permission to prepare and present this paper. Original presentation was at the annual meeting of the NGAA, Fort Worth, April 12-13, 1956.

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Meet the Authors

Kilmer

Rahmes

Lawler

JAMES W. KILMER is chief mechanical engineering supervisor for Stanolind Oil and Gas Company in Tulsa. He joined the company in 1947 as a gas engineer at Tulsa, and became process engineering group leader in 1951. He held that position until he received his present assignment in 1954. Kilmer is a chemical-engineering graduate of Rensselear Polytechnic Institute. After a five-year stint in the Army during World War II, he entered Texas A&M College where he took his master's degree in chemical engineering. While at Texas A&M, Kilmer was an instructor in the Chemical Engineering department.

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M. H. RAHMES was graduated from the University of Cincinnati in 1940 with a degree in chemical engineering. After five years in the Army, he entered the University of Tulsa, where he received his master's degree in petroleum refining in 1947. Rahmes joined Stanolind Oil and Gas Company in 1948, as a junior process engineer in the Tulsa general office. In 1951, he was named senior process engineer. He now is Process Engineering group leader.

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H. L. LAWLER completed his B.S. degree in chemical engineering at the University of Colorado in 1941, and now is working on his master's degree at the University of Tulsa. Lawler joined Stanolind Oil and Gas Company in 1947 as a chemical engineer in the Research department at Tulsa. The next year he was transferred to the Superior refinery at Vivian, La., as refinery engineer. In 1949 he went to Elk Basin, Wyo., as plant and operating engineer. The following year, he was named plant and operating engineer at the Slaughter gasoline plant near Sundown, Texas, and in 1951 returned to Tulsa as a mechanical engineer in the general office.

HOW THE SULFUR PROCESS DEVELOPED

Since C. F. Claus[1] obtained his patent in 1883[2] for the recovery of sulfur from hydrogen sulfide according to the following reaction, many changes have been made in the mechanical equipment,

$$H_2S + \tfrac{1}{2}\,O_2 \text{ - - - - } S + H_2O$$

The reaction was carried out in a kiln packed with catalyst. Although Claus endeavored to cool the kiln with water tubes, his efforts were unsuccessful and it was necessary to provide a very large surface to dissipate the heat by radiation. Feed rates were very slow, being in the order of 2-3 cu. ft./cu. ft. of catalyst per hour for an over-all production of about 15 long tons of sulfur per week from the average size plant.

The Germans[1] made many improvements on the original Claus process with the main emphasis being placed on contact catalysis and the removal of heat by means of a boiler. In the German modification one-third of the hydrogen sulfide in the inlet stream was burned to sulfur dioxide, and the latter then reacted over a catalyst with the remaining two-thirds of the initial hydrogen sulfide feed to yield elemental sulfur as shown in the following reactions,

1. $H_2S(g) + 3/2\,O_2(g) = SO_2(g) + H_2O(g) +$ 221,800 Btu/pound mol H_2S
2. $SO_2(g) + 2H_2S(g) = 3/8\,S_8(g) + 2H_2O(g) +$ 44,900 Btu/pound mol SO_2
3. $3H_2S(g) + 3/2\,O_2(g) = 3H_2O(g) + 3/8\,S_8(g) +$ 266,700 Btu/3 pound mols H_2S

These changes increased the thruput approximately 100 times. Sulfur recovery in the original Claus reaction rarely exceeded 85 percent, whereas yields of 93-94 percent could be obtained with the German modified-Claus process.

Later modifications of the Claus process involve the addition of the combustion air directly to the entire feed gas stream, after which the mixture is passed through a combination combustion chamber-waste heat boiler in which 50-65 percent of the hydrogen sulfide is converted into sulfur. The effluent gas may be cooled for removal of sulfur before it is passed over a catalyst for further conversion of the remaining hydrogen sulfide and sulfur dioxide. This modification is often referred to as a "straight-through" process. Either of the modified schemes may employ a single reactor or two reactors with intermediate cooling for removal of sulfur. ##

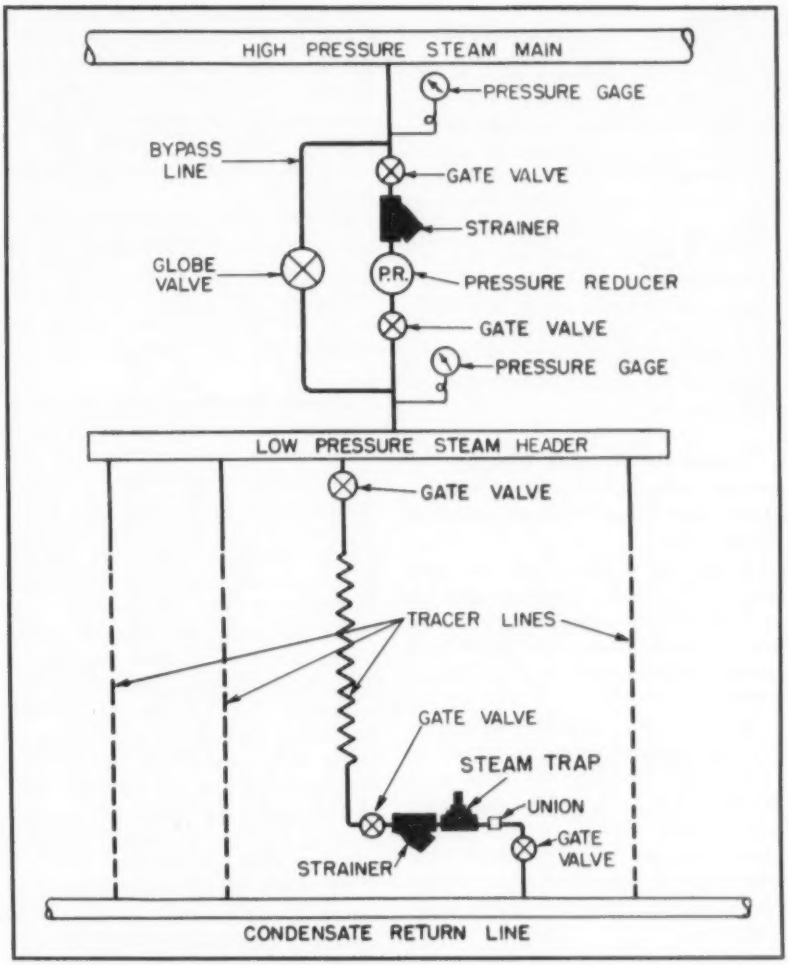

FIGURE 1—Typical steam tracing system.

How to Steam Trace Refinery Piping

For best results, make certain your steam traps and condensate lines are sized properly. These charts and data should help you.

J. Frank Long
Yarnall-Waring Company, St. Louis, Mo.

A WELL-ENGINEERED steam tracing system is the key factor in control of a process condition or reliable cold weather operation. To avoid costly downtime it is essential that control of fluid viscosity, temperature, crystallization and freeze-up be maintained.

Generally, no effort is made to produce a temperature rise by steam tracing. Instead a certain temperature is held. Raising the temperature of the liquid in transit is an entirely different problem.

Steam-Traced Equipment—Refining and petrochemical equipment on which steam tracing may be used includes all types of liquid lines—material in process, product, water, catalyst, waste, instrument leads—valves, pump casings, sight glasses, expansion joints, meter boxes, liquid-level gages, flanges, pressure-regulating valves, storage tanks, process tanks, and many other devices. Regardless of the unit served, the key factor involved in the heat release process is condensation of some or all of the steam in the tracer line. This results in transfer of energy in the form of heat to the traced pipe or vessel.

Other Methods—A similar effect using different heating mediums can be produced. Electric heating cables, hot-water tracing, and resistance heating in the line itself are used.

Electric heating cables are used where the cost of electricity is low; where steam is not available for tracing; or where the process requirements are such that steam or hot water is unsuitable. Spot or short-length applications of electric heating are usually the most economical, whereas long runs and large areas are usually better suited to steam tracing.

Hot-water and other hot fluid tracing falls midway between steam and electrical methods. It is suitable for runs of moderate lengths and for medium-size areas. Hot fluid does not release as much heat as steam, per pound circulated. It is usually considered to be unsuitable for long runs and large area.

System Components—The usual steam tracing system (Figure 1) consists of: A pressure-reducing station connected between the high-pressure steam header and the steamtracing header. One or more tracing lines. Steam traps for draining condensate from the tracer lines. Means for condensate disposal. Since each of these components is important in system design and application, they will be discussed individually.

Pressure-Reducing Station—Low pressure or medium-pressure steam, 10 to 200 pounds per square inch

gage, is generally used for steam tracing, pressures of 15 to 30 psig. being the most common. With low pressures, valves, fittings and other parts of the system need not be so heavy. Thus the initial cost of the system is reduced. Exhaust steam at about 15 pounds per square inch can be used as a source of heat for a tracing system. Many plants today use steam at higher pressures with a pressure-reducing station providing low pressure steam for tracing.

As normally designed, the pressure-reducing station consists of two steam pressure gages (one for the high-pressure side and one for the low pressure side), two gate valves, one globe valve, one strainer, one pressure-reducing valve and one relief valve. Bypass piping around the pressure-reducing valve permits routine maintenance and inspection of this valve without the necessity of shutting off the steam supply to the tracer system. During these periods the globe valve is used to throttle steam flow from the high to the low-pressure side of the system. A header is generally used when two or more independent tracer lines are fed by one pressure-reducing station. This permits using one station for a number of tracer lines, reducing initial and maintenance costs of the system.

Steam Tracing Lines—With a tracing pressure of 10 to 200 psig, Type K soft copper tubing or steel pipe is used to convey the tracing steam. Copper tubing possesses many advantages—it is light-weight, reasonable in cost and easily installed. It can be wrapped around pipes, fittings and tanks without the use of special tools. Successive lengths are easily joined. Adapters are available for connecting the tubing to the steel pipe used for the pressure-reducing station and the condensate drainage facilities.

The size of tubing used to trace a given pipe depends on three factors—tracing steam pressure, size of the main pipe and the amount of heat to be transferred to the main pipe. The smallest tube diameter used is ¼ inch, but ⅜ and ½-inch diameter tubing are used for most applications, especially the larger sizes of traced pipes. Where a single tracing line will not provide enough heat to maintain the desired temperature level, two, three, or four tracer lines can be applied to a single pipe. Table 1 lists several properties of copper tubing used for steam tracer lines.

Traps for Steam Tracing—To permit continuous transfer of heat, the tracer line is drained by means of a steam trap.

Either an impulse trap, or some form of bucket or thermostatic trap, is used for this service. Table 2 lists the maximum condensate capacity of ½-inch traps in each of the different types.

In this table tabulated capacities for the impulse trap are based on condensate entering the trap at a temperature 30 F. below the steam temperature. Traps of this design should be used where the back pressure in the return system comes within the limits recommended by the manufacturer.

Number of Traps Used—When impulse traps are used, a single trap can serve two, three or four tracer lines, depending on the quantity of condensate to be handled and the rated capacity of the trap. From the purely theoretical standpoint this might seem contrary to good engineering practice. However, it has proven quite satisfactory in many actual applications.

Where a single trap serves more than one tracer line, each line should be fitted with a check valve just ahead of the trap. This prevents the possibility of back-flow from one tracer line to another. Where tracer lines are wrapped around pipes, valves, and other apparatus, care should be taken to see that wherever possible the lines are sloped toward the trap in order to avoid large pockets of condensate at low points. This is particularly important where two or more tracer lines are drained by one trap.

It is a good practice to install a fine screen strainer just ahead of the trap. Use of a strainer protects the trap from any rust, dirt and other solid particles that may be carried through the piping system.

Return Line Size—Trap discharge lines and return mains must be large enough to carry away condensate and flash steam without causing excessive back pressure in the lines. The chart in Figure 2 correlates orifice size, factor of safety (or start up factor), back pressure and the equivalent length of the pipe between the trap outlet and the condensate return main. The factor of safety lines correspond to the factors used in the calculations for the trap size. In general, for steam tracing lines, a factor of safety of 2 is used. Thus, with a factor of safety of 2 and a condensate load of 160 pounds per hour, a trap suitable for handling at least 320 pounds per hour should be chosen.

The back pressure plotted in Figure 2 is the pressure in the return system (including vertical height above the trap at 0.5 psi per foot of height) in percent of inlet pressure at the trap. The equivalent length of pipe is the actual length of the discharge pipe in feet from the trap to the main or condensate collector, plus the pipe length equivalent of all the fittings in the line between the trap and the main.

Example: Determine the size of a 15-foot length of discharge pipe from

TABLE 1—Properties of Type K Copper Tube

DIAMETER			Wall	CIRCUMFERENCE		LENGTH OF PIPE Ft./Sq. Ft.	
Nominal	O.D.	I.D.	Thickness	External	Internal	External	Internal
⅛	.250	.186	0.032	.785	.585	15.290	20.500
¼	.375	.311	0.032	1.178	.977	10.200	12.290
⅜	.500	.402	0.049	1.570	1.263	7.650	9.500
½	.625	.527	0.049	1.964	1.655	6.110	7.250

TABLE 2
Condensate Discharge Capacity of Three Types of Steam Traps

Steam Pressure	½" Steam Traps Discharge Capacity In Pounds of Water per Hour		
	Impulse	Bucket	Thermostatic
5	140	450	1915
10	235	560	2695
15	285	640	3290
20	325	690	3780
30	400	500	
40	450	550	5290
50	490	580	5885
60	525	635	6400
70	570	660	
80	600	690	7310
100	645	640	8120
125	700	680	8925
150	745	570	9775

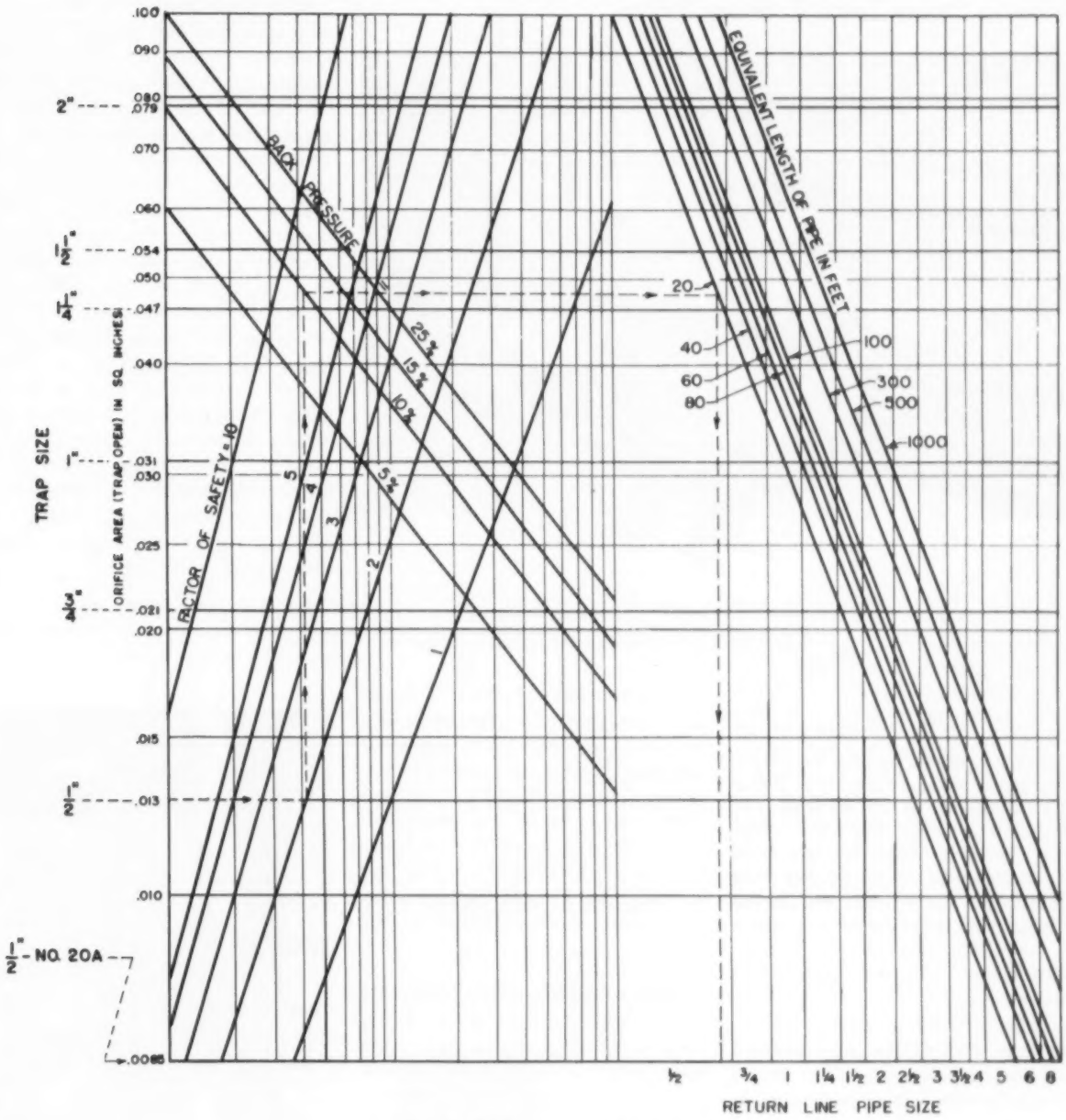

FIGURE 2—Condensate-line sizing chart.

PIPE SIZE (IPS)		½	¾	1	1¼	1½	2	3	4	6	8
Internal Transverse Area—Sq. In.		.304	.533	.864	1.50	2.04	3.36	7.39	12.73	28.89	51.16
Equivalent Length of Pipe in Feet	Elbow	1.6	2.2	2.8	3.7	4.5	5.5	8.0	11.5	16.0	21.0
	Tee	3.5	4.5	5.8	8.0	9.0	12.0	17.5	22.0	34.0	44.0
	Check Valve (open)	4.0	5.5	7.0	9.0	11.5	14.0	20.0	26.0	40.0	53.0
	Gate Valve (open)	.35	.50	.60	.80	.95	1.2	1.7	2.4	3.5	4.6
	Globe Valve (open)	17	21	29	38	45	56	80	120	170	230

a ½-inch trap on a steam tracer line to a return header 10 feet vertically above the trap. Inlet pressure at trap is 150 psi and pressure in return system is 10 psi. Fittings in discharge line—one elbow and one tee.

Solution: Back pressure = 10 psi + (10 ft. × .5) = 15 psi = 10 percent of 150 psi inlet pressure. Equivalent

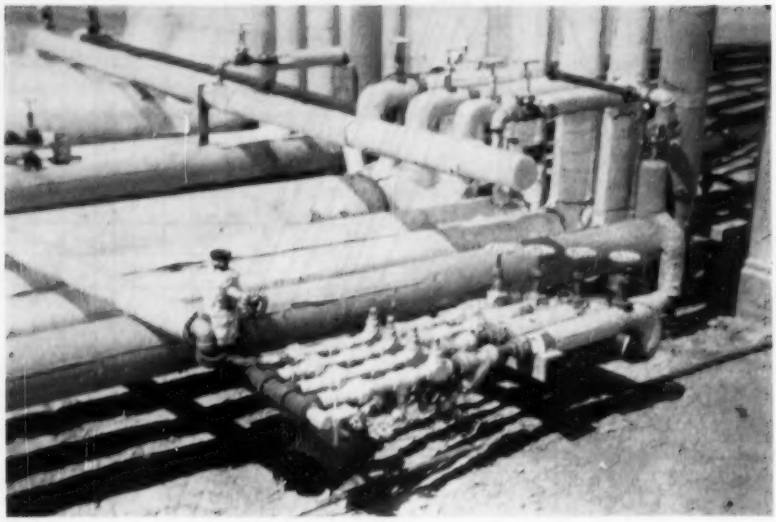

FIGURE 3—Typical condensate manifold.

Pipe Insulation—The tracer line and main pipe are enclosed by the same insulation, with a spacer on the bottom of the main pipe to provide clearance for the tracer line. Where reduction of heat loss is important, it is common practice to wrap the tracer line and main pipe with aluminum foil before the spacer and heat insulation are applied. This type of construction is somewhat more expensive than use of only one insulation but it insures minimum heat loss. To assure maximum heat transfer between the tracer and the main pipe, it is important that the tracer be in direct contact with the pipe. If there is an air gap between the tracer and the main pipe, much of the effectiveness of the tracer line will be lost. Insulation for the main pipe is usually selected of the next larger size to allow room for the tracer line.

length of pipe = 15 ft. (length of pipe) + 1.6 (½ inch elbow) + 3.5 (½ inch tee) = 20.1 ft. Factor of safety for steam tracer line = 2. Enter the chart at the ½ inch trap size. Follow the dotted line horizontally to the factor of safety line (2). Follow up (or down) to the back pressure line (10 percent). Continue horizontally to the right to equivalent length of pipe (20 feet), and drop down vertically to read size of discharge pipe, which in this example is ½ inch. **Note:** Each section of a return main must have large enough internal area to carry away condensate from all traps discharging into it. Add together the areas of each discharge pipe for minimum area of main return pipe. Mains may be graduated in size for economy of piping.

Trap Installation—When traps are used it is usual practice to leave the tracer line trap uninsulated because the heat loss is negligible. It is easier to inspect and maintain the trap when it is not covered by insulation. A permanent blow-off line with a valve is recommended for the strainer ahead of the trap. This can serve in lieu of a bypass should the trap become inoperative. The discharge from the strainer will serve as a reminder to the maintenance department that a trap requires servicing.

Where a large number of tracer lines are used in a plant and they all discharge near a common point (Figure 3), the usual procedure is to group the traps together. This arrangement makes a neat installation and allows easy inspection and maintenance of the traps. Each trap has its individual inlet and discharge lines, but a common return header is provided.

Return System—When condensate is discharged to atmosphere, it has been found an excellent plan to use a discharge manifold or "steam whirl" to receive the condensate from several traps. This manifold, shown in Figure 4, usually takes the form of a vertical cylinder, which may be made of a 3 or 4-foot section of 6-inch pipe with a vent on each end of 1¼-inch pipe. Horizontal discharge lines from the traps are attached to the side of the manifold. Trap discharge produces a whirling or centrifugal action inside the manifold. Condensate drains out the bottom vent and flash steam that is not condensed on the walls of the manifold issues from the upper vent. A manifold of this type is adequate to handle the discharge of about half a dozen ½ inch traps.

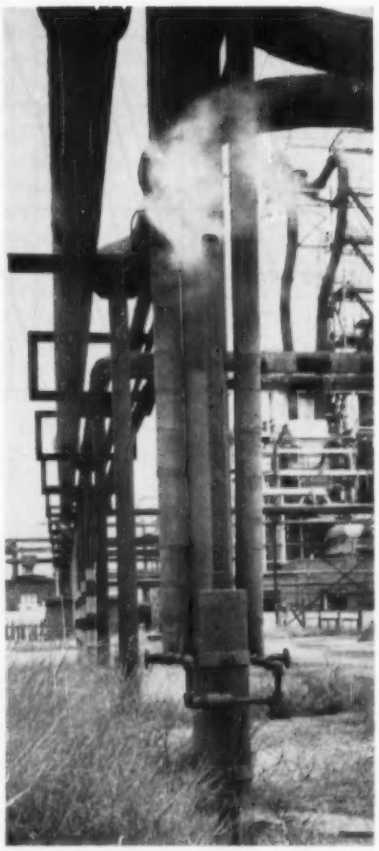

FIGURE 4—Discharge manifold.

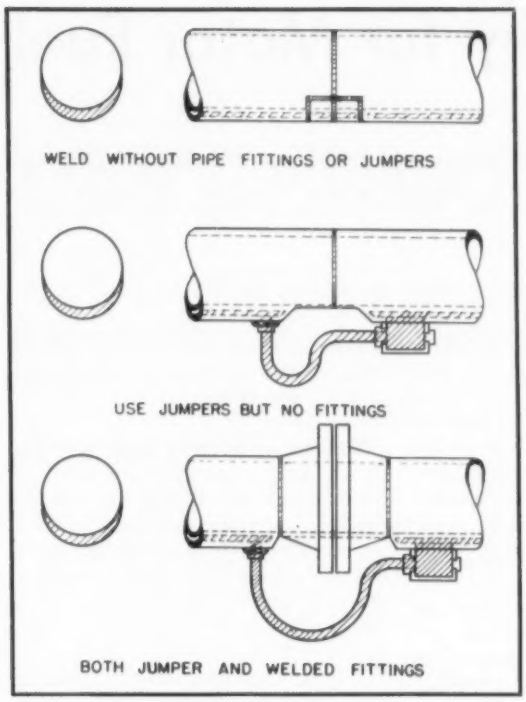

FIGURE 5—Integral jacketed piping.

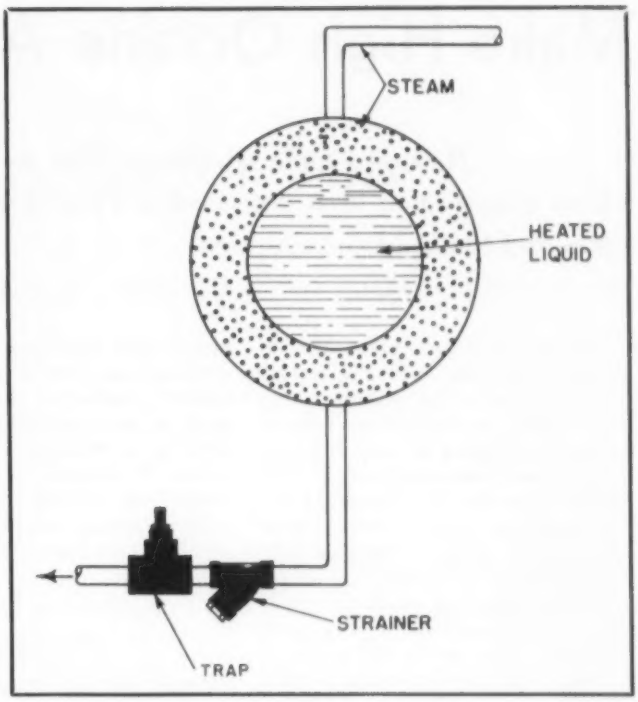

FIGURE 6—External jacketed piping.

A solid heat-transfer medium consisting of graphite, clay and a sodium silicate binder has been developed for insulating steam traced pipes. Applied in the form of a plaster or putty which dries on the pipe or valve, the solid heat-transfer medium reduces external heat losses and produces a more rapid temperature rise in the unit which it covers. Tests show that valves insulated with this compound attain a temperature approaching that of a completely steam-jacketed valve within one hour after steam is admitted to the tracer.

Tracer Expansion—Tracer lines are subject to expansion. Long tracer lines should have expansion loops at suitable intervals. These loops may be wound circumferentially around the exterior of the pipe, under the insulation, or they may be run along the centerline of the pipe.

Where an expansion joint is used in the main pipe, an expansion loop should be provided in the tracer line.

Valving Tracer Lines—Careful planning of tracer-line valve arrangements is necessary to insure good operation. Also, loss of the protection offered by steam tracing may require shutdown of one or more processes. To prevent steam waste during process—unit shutdown or turnaround and to permit maintenance, the tracing lines should have block valves.

Individual steam and condensate shutoff valves for each tracer line and branch tracer line, provide the simplest and most effective means of controlling steam and condensate flow. These shutoff valves should be grouped at a single location.

Jacketed Piping—Steam-jacketed piping is usually made in either of the two types: (1) with integral jacketing, Figure 5, or (2) with external jacketing consisting of two pipes, one inside the other, Figure 6. In the first arrangement the steam flows only along the underside of the pipe, while in the second it entirely surrounds the heated pipe.

The arrangement shown in Figure 5 is a relatively recent development which is suitable for either steam tracing or steam heating of the liquid conveyed. The piping is made of aluminum and is recommended for handling molten sulfur, ammonium nitrate, glacial acetic acid, fatty acids, tar, pitch, etc. Insulation for the next larger size pipe is used; for example, a 2-inch pipe uses insulation suitable for a 2½-inch pipe. ##

Meet the Author

J. FRANK LONG has been associated with Yarnall-Waring Company 15 years, the past four and a half of which have been as district manager of the company's St. Louis territory. Before joining Yarnall-Waring, he served four years in the Operating department of Tidewater Associated Oil Company's Eastern division. And before that he was engaged four years in construction work for the Pennsylvania Department of Highways.

Make High Octane Alky for Motor Fuel

Here are some additional data on the products from an alkylation process which already had been described in PETROLEUM REFINER. Check the high octanes and low acid consumption.

TODAY ACTUAL plant data on an alkylation unit with effluent refrigeration makes the alkylation process potentially attractive from a motor gasoline standpoint as well as in the manufacture of aviation gasoline. Two factors enter into the picture: First, the alkylation process with effluent refrigeration operates with an acid consumption of 0.3 pounds per gallon of alkylate produced which is equivalent to a catalyst cost of 12½ cents per barrel (acid costing $20 per ton); Second, total alkylate with a clear CFRR octane in the range of 95 to 97 is produced. The 3-C performance number of aviation alkylate at 4.6 cc's TEL exceeds the rating scale of 161 and is calculated as high as 165 to 166.

There is another side of the picture which makes alkylation attractive at the present time. The C_4 cut from catalytic reforming is entirely paraffinic and usually contains 50 percent or more isobutane. All of this isobutane plus isobutane from catalytic cracking can not be blended into finished gasolines so that a part of it must be used as fuel gas or sold as LPG for a relatively small monetary return. If isobutane is alkylated with olefins from refinery gas, the product is an extremely valuable gasoline for use as a high octane blending agent in motor fuel.

In the alkylation process used at The Texas Company's Amarillo refinery, there are two isobutane recycle streams—the deisobutanizer overhead and the flashed condensate return from the refrigeration system. As a result, an isobutane to olefin ratio as high as 12:1 can be maintained and isobutane in reacted mix under good operating conditions is 80 percent. The high isobutane recycle ratio is the result of using isobutane as a refrigeration medium whereby approximately 50 percent of the isobutane in the reacted mix is flashed out after leaving the reaction zone. This isobutane is then returned as recycle without the necessity of processing through the deisobutanizer tower.

The exceptionally high quality of alkylate produced and the low acid consumption are directly related to the high isobutane recycle ratio. During periods of isobutane shortage there is a marked increase in acid consumption and the 3-C performance number of alkylate at 4.6 cc's TEL drops as low as 150.

The acid consumption of 0.3 pounds per gallon and performance numbers of 165 to 166 are representative of normal operation during periods when adequate supply of isobutane is available. Typical inspection data for aviation and total alkylate are shown in Table 1.

Quality of aviation alkylate is such that it can be readily blended with base stocks and pressuring agents for production of 115/145 grade aviation gasoline. It is not necessary to use aromatics with the aviation alkylate in order to meet performance number of 115/145 aviation gasoline.

Use of the total alkylate stream as a high octane blending agent for motor gasoline offers a method of reaching the high octane level without necessity of extremely severe cracking or reforming. The material does not need to be rerun.

A complete description of The Texas Company's Amarillo unit was given by Goldsby and Putney (Stratford Engineering Corporation, Kansas City, Kansas) in the September, 1955, issue of the PETROLEUM REFINER, starting on Page 148. This additional information on the products from that unit was condensed from a paper by Templeton and King (The Texas Company, Amarillo, Texas) for presentation before the Western Petroleum Refiners Association meeting in Wichita, Kansas, on June 22, 1956.

##

TABLE 1
Typical Alkylate Data

	Aviation Alkylate	Total Alkylate
Gravity, °API	71.4	68.7
Sulfur	0.000	0.000
Corrosion at 212° F	Neg.	Neg.
Gum, mg/100 cc		
Copper Dish	1	11
ASTM	0	3
RVP, psi	4.6	3.0
Distillation		
IBP	108	118
10% E	164	175
20% E	184	191
50% E	212	214
90% E	230	252
End Point	314	372
Recovery, Percent	99.0	99.0
F-4 Performance No.		
+ 4.0 cc TEL	159.5	.....
+ 4.6 cc TEL	165.0*	.....
CFRR Octanes		
Clear	....	96.8
+ 1.5 cc TEL	....	Iso + 0.50
+ 3 cc TEL	....	Iso + 1.00*

* Calculated.

What Unifining Can Do for You

Unifining can profitably answer the challenge of low quality crude and can be integrated into an existing operation.

Harry F. Poll
Union Oil Company of California
Brea, Calif.

MOST REFINERS today are confronted with increasing demand for higher quality products while faced with the problem of refining lower quality crudes. The incremental crudes are often of higher sulfur content and lower gravity. They present two major refining problems:

1. Low quality crudes make it difficult to achieve desired quality specifications. Today's products call for higher octane, lower sulfur, improved color, odor, stability or burning characteristics.

2. Low quality crudes make it difficult to produce the desired product distribution. Lower gravity and higher contaminants in the crude are obstacles to the refiner who tries to meet the product yield structure called for by customer demand. Here are Bureau of Mines figures for domestic demand in millions of barrels between 1946 and 1954, the latest year for which data were available:

Year	Motor Fuel	Mid-Distil. & Kerosine	Residual Fuel Oil
1946	735.4	332.0	480.0
1950	994.3	512.7	553.8
1954	1284.2	644.7	522.1

Therefore, while motor fuel and middle-of-the-barrel demand was rising 75 percent and 94 percent, residual fuel oil demand increased only 8 percent.

What Unifining Can Do—The Unifining process has been amply described in previous papers.[1, 2, 3]

Briefly, it is a catalytic hydrogenation process for upgrading hydrocarbon mixtures. The reaction is carried out in the presence of hydrogen and a cobalt-molybdate-type catalyst. It is extremely versatile, can handle any petroleum fractions to produce a variety of products. These in turn determine the selection of optimum process conditions.

The Unifining process has now had extensive commercial applications.[4] There are about 50 units with a capacity of some 400,000 barrels, either operating or in the design-construction stage.

Unifining can profitably answer the challenge of the low quality crude and be integrated conveniently into an existing refinery.

This point is best illustrated by discussing the refining of Santa Maria Valley crude. We choose this approach for two reasons:

- Containing 5 percent sulfur and with a gravity of 15° API, Santa Maria Valley (SMV) crude certainly qualifies as low quality.
- Union Oil Company of California has proven by actual commercial operation many of the processing steps discussed. Extensive experimental studies have provided a firm basis for predicting the others.

We will use the case method in our discussion. The cases we use are concrete, real and typical.

Case 1—Refining SMV Crude—No Unifining—For many years, Union has been faced with the very real problem of refining Santa Maria Valley crude. Table 1 shows some typical properties. The average crude is 15° API and contains about 5.0 wt percent sulfur and about 0.6 wt percent nitrogen. Actually, there are specific areas and wells that produce crude of only 8° API and sulfur as high as 6.5 wt percent. After removal

Meet the Author

HARRY F. POLL is supervising engineer in the Engineering division of Union Oil Company of California's Research department at Brea, Calif. Poll joined Trojan Power Company in 1941, following his graduation from Purdue University with a B.S. degree in chemical engineering. With Trojan, he worked in various phases of the explosives industry, and his experience there lead to a commission as an ordnance expert in the Navy during World War II. With Union Oil since 1946, he has worked in pilot plants, process design and process engineering. He was process engineering coordinator of the recent major refinery expansion of Union Oil, and has been closely connected with the engineering development of the Unifining process and its commercial process design and application.

What Unifining Can Do for You . . .

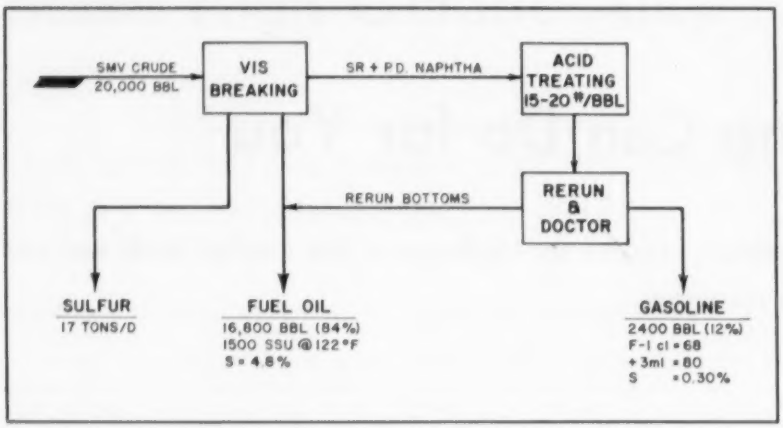

FIGURE 1—Simplified flow diagram—Refining Santa Maria crude. Case 1—No Unifining.

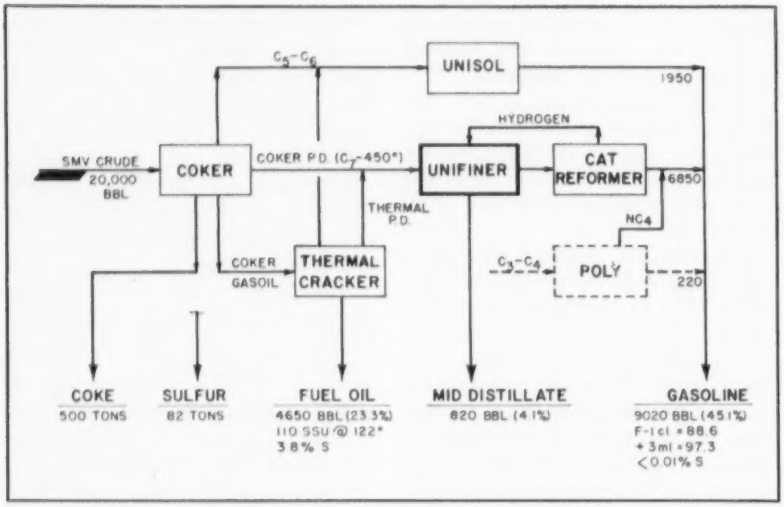

FIGURE 2—Case 2—Unifining coker and thermal P.D.

of about 13 vol percent gasoline the residuum is essentially an asphalt. In fact, it is almost marketable, as such, for SC-4 road oil. But nobody wants this much road oil; and the gasoline is inferior due to low octane and high sulfur.

TABLE 1
Typical SMV (Calif.) Crude

Gravity, °API	15.0
Viscosity, SSF at 122 F	240
Sulfur, weight percent	5.0
Nitrogen, weight percent	0.63
400° EP fraction, vol. percent of crude	13.3
Gravity, percent	53.6
Sulfur, weight percent	0.61
Nitrogen, weight percent	0.003
Knock Ratings:	
F-1 clear	57.0
F-1 + 3 ml TEL	71.5
Residuum, volume percent of crude	86.7
Gravity, °API	10.2
Viscosity, SSF at 210 F	90
Sulfur, weight percent	5.80
Nitrogen, weight percent	0.75

Until a few years ago, about all that could be done was to perform a light visbreaking operation on the crude, then acid treat, rerun and doctor treat the resulting naphtha. Figure 1 shows a simplified flow diagram of this ineffective method of refining 20,000 barrels of SMV crude. Gasoline yield, based on crude, is only 12 percent. It would be a simple matter to increase the severity of cracking to produce more gasoline, but the sulfur content would then be too high to handle by acid treating. Table 2 shows the acid treating of SMV naphtha produced from the light visbreaking operation of Figure 1. Even under these conditions thermal naphtha contains 1.28 wt percent sulfur. It requires a 15-20 pound treat, plus undercutting of the end point, to give a product with 0.30 wt percent sulfur and octane of 80 F-1 + 3 ml. Today's standards would permit blending only small amounts of this inferior gasoline. The over-all acid treat, rerun and doctor yield is only 72 vol. percent, based on feed to acid treating.

TABLE 2
Acid Treating SMV Naphtha
Acid Treat = 15-20 lbs/bbl

	Feed to Acid Treat	Product After Acid Treat Rerun and Dr Treat*
Gravity, °API	55.1	59.3
ASTM:		
IBP	110	116
10 percent	179	175
50 percent	261	249
90 percent	322	307
Maximum	390	356
Sulfur, weight percent	1.28	0.30
RVP	....	6.0
Octanes:		
F-1 Clear	....	68
+ 3 ml.	....	80
Volume percent	100.0	72

* Product E.P. lowered to reduce sulfur content.

Case 2—Refining SMV Crude—Unifining Coker and Thermal P. D.—The development of the Unifining process permitted drastic improvements in refining SMV crude. It was now possible to increase the yield of desired light fractions and still refine them to marketable specifications.

Coking is a convenient way of improving the yield structure of a low quality crude such as SMV. Table 3 shows typical commercial data from Union's coking operation. Two liquid product streams are produced—36 vol percent coker naphtha fraction containing almost 2 wt. percent sulfur; and 44 vol percent of coker gasoil containing almost 4 wt percent sulfur. Coke yield is 15 wt percent.

Figure 2 shows the over-all commercial operation on SMV crude made possible by the installation in February, 1955, of a Unifining unit at Union's Oleum refinery.

The simplified flow diagram shows that Unifining is actually the key to the whole technology. The coker, as already discussed, produces coker naphtha and gasoil. The coker gasoil is thermally cracked to further increase the naphtha yield and reduce fuel oil. The combined high-sulfur cracked naphthas are dehexanized and pass to the Unifiner where essentially all contaminants are removed. The product of Unifining is then fractionated into high quality catalytic reformer feed and premium

stove oil fraction suitable for blending into various mid-distillates.

The 380° EP naphtha after Unifining flows to a catalytic reformer producing a reformate of 97.5 F-1 + 3 ml. Excellent run lengths and high product yields are achieved.

The cracked C_5-C_6 fraction is treated in a Unisol plant for removal of mercaptan sulfur. After Unisol treating it has an F-1 + 3 ml octane of 95.5. It could have been sent instead to the Unifiner and catalytic reformer.

The cracked C_3-C_4 fraction is shown going to a polymerization unit. It is shown with dashed lines because this is an optional choice. It may be preferred to merely desulfurize the B-B fraction with a regenerative caustic wash and blend it directly into gasoline; depending upon the overall vapor pressure balance in the refinery.

Note that with presently operating facilities Union can now convert SMV crude into a product yield structure of 45.1 percent gasoline, 4.1 percent mid-distillate and 23.3 percent fuel oil, all based on crude. This compares with only 12 percent gasoline and 84 percent fuel oil formerly achieved. In addition, gasoline quality has been improved from 80 to 97.3 F-1 + 3 ml octane; and sulfur reduced from 0.30 wt percent to less than 0.01 wt percent. Hydrogen sulfide, which is converted into elemental sulfur, is a valuable byproduct. Another byproduct is coke.

Table 4 summarizes typical commercial data when Unifining SMV cracked naphtha. Attention is called to the almost total conversion of sulfur and basic nitrogen. This is accomplished at a liquid yield of 101.0 vol percent. The first commercial run lasted about nine months at which time the unit was shut down for equipment and corrosion inspection. No catalytic activity decline had been noticed up to this time. And, incidentally, the inspection showed no significant equipment or corrosion problems. Since the unit was down for inspection, the catalyst was regenerated as a matter of routine. It started up again smoothly and has been running continuously. To date it has processed sufficient charge to bring the catalyst cost down to about 1.5 cents per barrel. A conservative estimate is that Union's catalyst life will bring this cost down to .5 cent per barrel, or less.

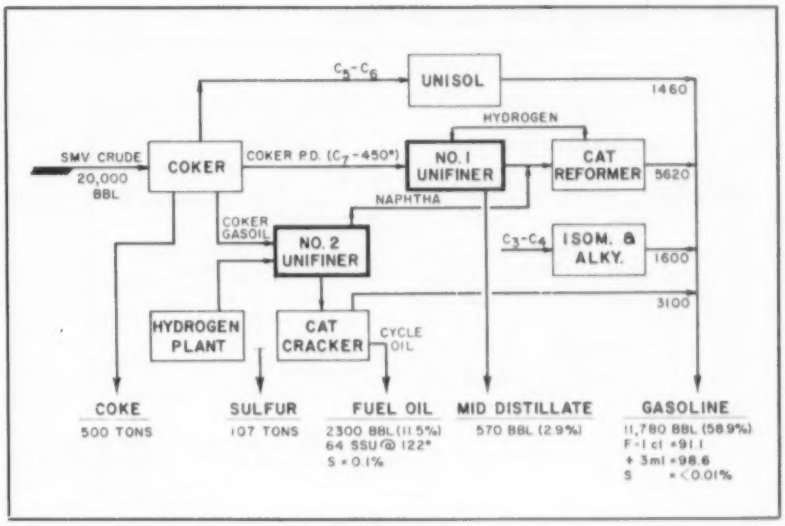

FIGURE 3—Case 3—Unifining total coker distillate.

The representation of this case is naturally highly simplified. Actually other collateral streams are processed through the same refinery units. The extraneous streams were not shown so that the processing of SMV crude could be isolated and examined by itself.

TABLE 3

Delayed Coking of SMV Crude

PRODUCTS	
Coker Naphtha Fraction (100-450 F.)	
Volume percent of crude	36
Gravity, °API	49.5
Sulfur, weight percent	1.90
Nitrogen, weight percent	0.03
Vapor pressure, RVP	7.5
Coker Gasoil Fraction (450-750 F.)	
Volume percent of crude	44
Gravity, °API	24
Sulfur, weight percent	3.80
Nitrogen, weight percent	0.30
Viscosity, SSU at 122 F	40
Coke, weight percent of crude	15
Sulfur, weight percent	5.3

TABLE 4

Unifining SMV Cracked Naphtha*

	Charge	Products	
		Reformer Feed	Stove Oil
Gravity, °API	47.8	55.0	38.6
ASTM Dist., F.:			
IBP	190	152	390
10 percent	230	212	
50 percent	300	270	415
90 percent	400	340	
E.P.	450	380	490
Sulfur, wt. percent	1.90	0.005	0.01
Doctor Test	Sour	Sweet	Sweet
Basic Nitrogen, PPM	225	0.2	1.0
Olefins, vol. percent (FIA)	17	<1	<1
Liquid Yield, vol. percent of charge	....	101.0	
Hydrogen Consumption, scf/bbl	....	400	

* Commercial Data.

Cases 3, 4 and 5—Refining SMV Crude—Unifining Total Coker Distillate—In the first *two cases* were *commercial operating* examples. Now what improvements that could be achieved by application of still additional Unifining capacity? These are *hypothetical cases* to serve a purpose of illustration.

Assume that the objective is to maximize gasoline yield and quality. How far this objective can be profitably carried out is a function of detailed economic studies which vary for each refiner. These important considerations will be given some brief comment later. For the present consider some realistic process possibilities, labeled Cases 3, 4, and 5. Each has the same basic scheme; a second Unifiner to treat high sulfur coker gasoil so it can be processed in a catalytic cracker.

Figure 3 is a simplified flow diagram of Case 3. Here is a refining arrangement similar to Case 2, except that coker gasoil, as just described, is processed through the second or No. 2 Unifiner and a cat-cracker. Previously, it had been thermally cracked. A hydrogen plant is also shown. It is possible that insufficient excess reformer hydrogen is available. One more new change is the replacement of polymerization by isomerization and alkylation.

For a case which includes catalytic cracking, and therefore high percent-

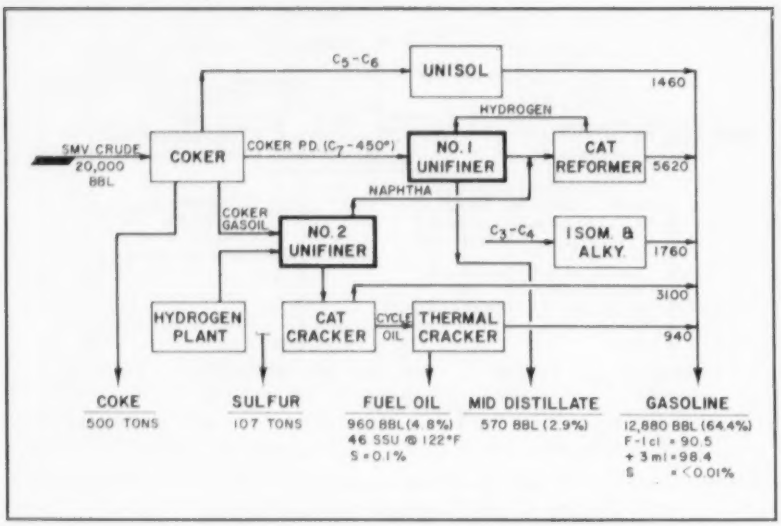

FIGURE 4—Case 4—Unified total coker distillate plus thermal cracking cycle oil.

ages of butylene and isobutane production, this should be more realistic. The steady rise in motor fuel octanes gives indication that motor fuel alkylation of cracked C_3-C_4 mixtures will increase in attractiveness. We assume in cases 3, 4, and 5 that there are about 500 barrels of outside butane available to alkylate all recovered C_3 and C_4 olefins.

Examination of the product yield structure for postulated Case 3 shows that gasoline yield would increase to 58.9 vol percent with an average octane of 98.6 F-1 + 3 ml; as compared to 45.1 percent and 97.3 F-1 + 3 ml in Case 2. Mid-distillate yield drops slightly because the No. 1 Unifiner no longer processes 450° EP thermal P.D. Fuel oil yield drops from 23.3 vol percent to 11.5 vol percent. Note that this fuel oil is comprised entirely of catalytic cycle oil. This is an over-simplification designed to show the maximum fuel oil production. It is likely that a reasonable proportion of this material, particularly the light cycle oil, could be blended into mid-distillate by many refiners.

Table 5 shows the estimated commercial data for Unifining SMV coker gasoil. It is based on extensive laboratory data. High conversions of sulfur, nitrogen and olefins are accomplished. Total liquid yield is 101.8 vol percent. The total product is shown fractionated into two components; 14.8 vol percent of 400° EP naphtha and 87.0 vol percent of 420°-750° gasoil. The removal of sulfur atoms from high-boiling compounds produces lower boiling hydrocarbons in the naphtha range. Very little hydrocracking takes place. The naphtha is suitable for cat-reforming and is so shown.

Table 6 presents estimated commercial catalytic cracking results on the gasoline-free SMV gasoil after Unifining. It assumes a commercial operation at 70 percent conversion and recycle-to-fresh-feed-ratio of 0.5. It is based upon once-through laboratory data.

Pertinent items to note are the high octane of the gasoline (100 F-1 + 3 ml) and its low sulfur content (0.01 wt percent). Yet these results are accomplished on an original gasoil of 3.80 percent sulfur and 0.30 percent nitrogen, totally unacceptable, without Unifining, as cat-cracker feed. In addition, 14.8 percent naphtha is produced in the Unifining unit which can be processed through a cat-reformer.

Cases 4 and 5 are identical with Case 3 except for the method of handling the catalytic cycle oil. Case 3 assumed the cycle oil would go directly to fuel oil.

Case 4, shown in Figure 4, assumes cycle oil will be thermally cracked. This increases gasoline to 64.4 vol percent and reduces fuel oil to 4.8 vol percent.

Case 5, shown in Figure 5, assumes cycle oil will be recycled back to the Unifiner and cat-cracked to extinction. This may be considered an "ultimate" case. It produces 67.2 vol percent gasoline with an octane rating of 98.8 F-1 + 3 ml; and 2.9 vol percent of mid-distillate. No fuel oil is produced.

Table 7 shows a product summary comparison of all five cases. Its contents have been mostly covered under the discussions of each case. Note the trend toward higher gasoline yield and quality and lower fuel oil yield with each case. The total liquid yield figures show up an interesting point. If we ignore the high liquid yield for Case 1, which actually encompasses

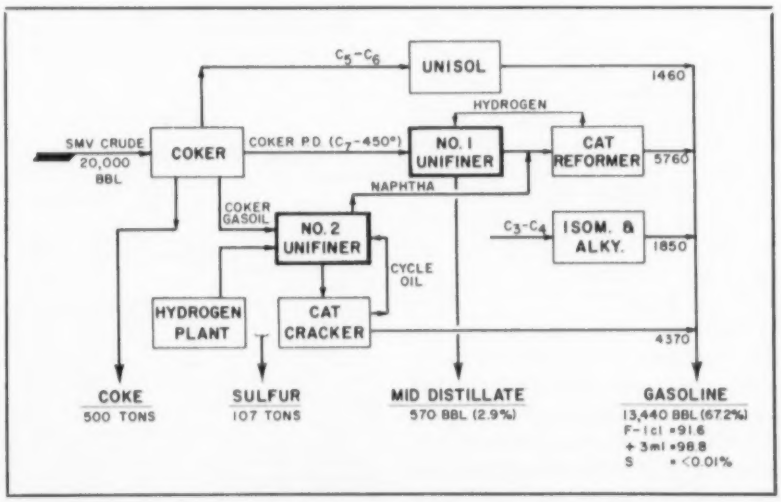

FIGURE 5—Case 5—Unifining total coker distillate plus Unifining cycle oil.

negligible refining of the crude, we note that there is but slight difference in the total liquid yield for the remaining Cases 2 through 5. The basic reason is that Unifining was used to obtain the progressive improvements in yield structure. Unifining usually shows liquid yields in excess of 100 vol percent. And in addition, it improves the efficiency of the other units which process charge stocks from Unifining.

Increasing Mid-Distillate Yield—It was noted that the case studies were based upon maximizing gasoline yield. It is possible that many refiners would find it more desirable to increase the yield of marketable premium mid-distillate at the expense of reduced gasoline yield. This is readily accomplished by increasing the end point of the Unifiner feed to include the fractions which will give the desired quantity and character of mid-distillate products.

Table 8 presents laboratory data to illustrate this flexibility. It shows laboratory data for Unifining combined SMV cracked naphtha and straight run SMV diesel fraction. The charge comprises a blend of 75 percent cracked naphtha with a 450° EP and 1.90 wt percent sulfur of the character already discussed and 25 percent of 650° EP straight-run diesel fraction containing 2.9 wt percent sulfur. The combined blend is readily processed in a Unifining unit to produce a total product that can be fractionated to about two-thirds 380° EP reformer feed, and one-third diesel fraction. The 380° EP fraction makes an excellent reformer feed. The diesel fraction has about 99 percent of the sulfur removed and CFR Diesel Index is increased almost six points.

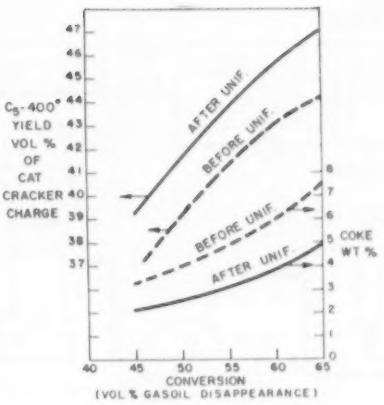

FIGURE 6—Catalytic cracking comparison (predicted commercial results) before and after Unifining virgin West Texas gasoil (1.8%).

Unifining—Catalytic Cracking West Texas Gasoil—A crude oil does not have to be as high in sulfur as SMV crude to attain marked improvement through Unifining. To illustrate this point we will consider a virgin West Texas gasoil. We assume that it is a combined atmospheric plus vacuum gasoil containing 1.8 wt percent sulfur. Our objective is to estimate cat-cracking results on the gasoil before and after Unifining. Our predictions will be based on correlations developed from laboratory studies.

Figure 6 is a plot of gasoline and coke yield versus conversion, both before and after Unifining the cat-cracker charge. It shows the typical reduction in coke and increase in gasoline yield expected from a gasoil of the assumed quality.

Table 9 provides tabular data for the same stock at a 60 percent conversion level. Gasoline yield increases 6 percent while coke is reduced 37 percent. Gasoline to coke ratio increases from 7.2 before Unifining to

TABLE 5

Unifining of SMV Coker Gasoil*

	Charge	Products	
		Naphtha	Gasoil
Vol. percent of charge	100	14.8	87.0
Gravity, °API	24	46.5	30.5
Sulfur, wt. percent	3.80	0.01	0.04
Nitrogen, wt. percent	0.30	0.02	0.10
Olefins, vol. percent (FIA)	16	<1	1
ASTM Dist. (IBP-EP), F	450–750	135–400	420–750
H_2 Consumption, scf/barrel	700	....	....

* Estimated comm. data. Based on lab. data.

TABLE 6

Catalytic Cracking of SMV Coker Gasoil After Unifining*

Basis: Conversion 70%
Recycle/F.F. 0.5

Yields, Based on F. F.:	
P-P, volume percent	6.5
B-B, volume percent	13.5
C_5-400° gasoline, volume percent	41.1
Combined cycle oil, volume percent	26.0
Slurry oil, volume percent	4.0
Coke, weight percent	6.4
Product Properties:	
C_5-400° Gasoline:	
Gravity, °API	55.0
Sulfur, weight percent	0.01
Octanes—F-1 clear	97
F-1+3 ml	100
Cycle Oil:	
Gravity, °API	24
Sulfur, weight percent	0.1

* Estimated from once-thru lab. data.

TABLE 7—Product Summary Comparisons—Refining SMV Crude

Basis: 20,000 B/D

	Case 1	Case 2	Case 3	Case 4	Case 5
Gasoline Yield, Vol. Percent	12	45.1	58.9	64.4	67.2
Barrels/Day	2,400	9,020	11,780	12,880	13,440
F-1 Clear	68	88.6	91.1	90.5	91.6
+ 3 ml	80	97.3	98.6	98.4	98.8
Sulfur, weight percent	0.30	<0.01	<0.01	<0.01	<0.01
Mid-Dist. Yield, Vol. Percent	0	4.1	2.9	2.9	2.9
Barrels/Day	0	820	570	570	570
Sulfur, weight percent	.....	0.01	0.01	0.01	0.01
Fuel Oil Yield, Vol. Percent	84	23.3	11.5	4.8	0
Barrels/Day	16,800	4,650	2,300	960	0
Sulfur, weight percent	4.8	3.8	0.1	0.1	.....
Viscosity, SSU at 122	1,500	110	64	46	.....
Total Liquid Yield, Vol. Percent	96.0	72.5	73.3	72.1	70.1
Coke, Tons/Day	.....	500	500	500	500
Sulfur, Tons/Day	17	82	107	107	107

TABLE 8—Unifining Combined SMV Cracked Naphtha and Straight Run SMV Diesel Fraction

	Charge	PRODUCTS		
		Total	380° EP Gasoline	Diesel Fraction
Gravity, °API	42.0	46.9	52.7	36.4
ASTM Dist., F.:				
IBP	220	192	197	410
10 percent	270	260	239	444
50 percent	354	345	294	483
90 percent	539	509	350	583
E. P.	614	600	378	632
Sulfur, weight percent	2.2	0.012	0.003	0.027
Nitrogen, weight percent	0.025	0.006	0.0006	0.016
Olefins, volume percent (FIA)	13	<1	.....	.....
CFR Diesel Index	(40.6)*	.....	.....	46.3
Yield, volume percent of Charge	.....	100.8	67.5	33.3
H_2 Consumption, SCF/Barrel	.....	360	.....	.....

* Diesel index of S.R. diesel used in blend.

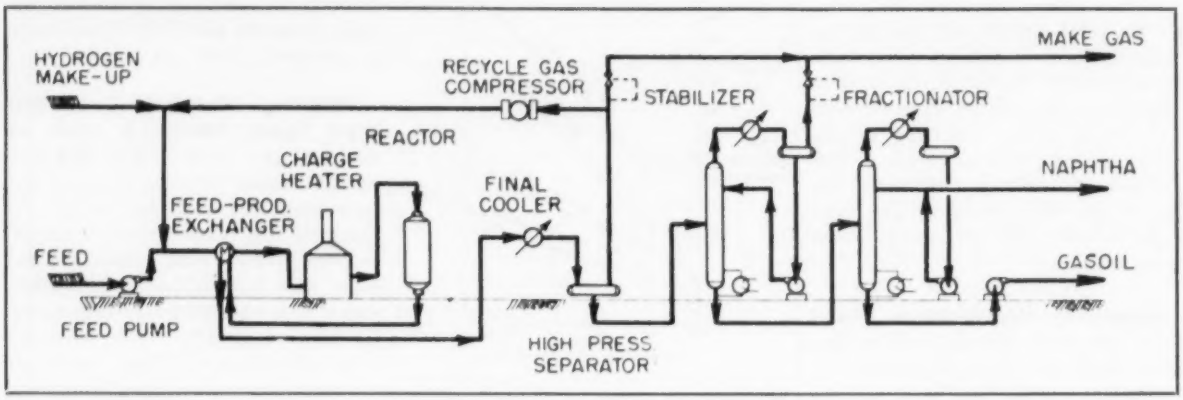

FIGURE 7—Simplified flow diagram Unifining process.

12.0 after Unifining. In addition, there are many quality improvements. Sulfur content of the catalytic gasoline is reduced from 0.15 wt percent to less than 0.01 wt percent; and octane increases from 97 F-1 + 3 ml to 99.5 F-1 + 3 ml. Cycle oil gravity increases 5 points and sulfur content is lowered from 1.5 wt percent to 0.1 wt percent.

The Unifining step shows a total liquid yield of 101.5 vol percent. The 9.5 vol percent naphtha produced in Unifining was not included in the cat-cracking results. It is available for direct blends or for processing through a cat-reformer if further octane improvement is desired.

Unifining Process Description—Figure 7 is a simplified process flow diagram of a Unifining unit. The feed is combined with recycle hydrogen, heat exchanged against reactor product and heated to the required reactor inlet temperature. Within the reactor the desired reactions are accomplished in the presence of the specially developed Unifining catalyst. The reactor product, after heat exchange against feed, flows to a final cooler and separator. The desired quantity of hydrogen-rich separator gas is recycled back to the reactor; and any excess is bled out of the system. The separator liquid is stabilized for removal of H_2S and dissolved light gases. A fractionator is shown which can split the product into two fractions.

The chemical consumption of hydrogen will vary with the nature of the feed. Make-up hydrogen is added to the system as required.

Unifining can employ a wide range of process conditions. The selection of optimum process conditions is based upon the nature of the feedstock, the desired quality of products, and on economic considerations.

Commercial experience has demonstrated the physical ruggedness of the catalyst and its ability to withstand repeated regenerations while retaining its exceptional activity.

Economics of Unifining—Unifining units are characterized by relatively low operating and investment costs. The No. 1 and No. 2 Unifiner applications used in this paper are estimated as follows:

	Capital Investment	Operating Cost
No. 1 Unifiner.	$100-$150/bbl	10¢/bbl
No. 2 Unifiner.	$150-$175/bbl	12¢/bbl

The capital investment figures include a product fractionator.

The operating costs include labor, utilities, catalyst, maintenance, insurance and property taxes. They exclude hydrogen cost, royalty and depreciation.

Hydrogen costs are excluded since they depend upon whether waste reformer hydrogen or manufactured hydrogen is used. At a fuel gas value of 15 cents per million British thermal units, waste reformer hydrogen has a value of 5 cents per 1000 standard cubic feet; on the other hand, manufactured hydrogen is estimated at approximately 35-45 cents per 1000 scf, depending upon hydrogen plant capacity.

Detailed economics for broad refinery schemes, such as the cases earlier described, are beyond the scope of this paper. Only the refiner can make a realistic appraisal of refining schemes which effect wide changes in his product yield structure and product qualities. The approach taken would be different for each refiner.

TABLE 9

Unifining and Catalytic Cracking Virgin West Texas Gasoil (1.8% S)

	No Unifining	Unifining
Unifining:		
H_2 Consumption, SCF/Barrel	....	400
Products:		
Total Liquid Yield, volume percent	....	101.5
Gasoline, vol. percent	....	9.5
Sulfur, wt. percent	....	0.01
Octane, F-1 + 3 ml	....	79
Gasoil, volume percent	100.0	92.0
°API	27.5	32.0
Sulfur, wt. percent	1.8	<0.1
Cat Cracking*:		
P.P. vol. percent of F.F.	9.0	8.0
B-B. vol. percent of F.F.	13.3	14.5
C_5-400° Gasoline, vol. percent of F.F.	43.0	45.5
Combined Cycle Oil, vol. percent of F.F.	40.0	40.0
Coke, wt. percent of F.F.	6.0	3.8
Product Properties:		
C_5-400° Gasoline:		
Sulfur, wt. percent	0.15	<0.01
Octanes—F-1 clear	92	92.5
+3 ml	97	99.5
Cycle Oil:		
Gravity	22.0	27.0
Sulfur, wt. percent	1.5	0.1

*Percent predicted comm'l. results at 60 percent conversion and no recycle.

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How to Invest Your Capital for Profits

This incremental present worth method of economic evaluation is applicable for all cases of capital investment.

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THE PROPER criteria for making decisions on investment of capital is currently a matter of considerable controversy. The method proposed here gives proper consideration to all major factors including risk. It may be used by management for . . .

- Appraisal of major projects
- Deciding when to shut down an existing operation and by engineers in detailed design decisions

The criterion proposed here is the incremental present worth, or the increase in cash value of the project over that which would be obtained if the total capital involved were invested in marginal projects.

The incremental present worth of a project includes:

- Present worth of income
- Tax credits
- Working capital
- Future salvage value

Less . . .

- Total investment in facilities
- Working capital

In the case of an existing operation, the immediate value of working capital, tax credits and salvage is subtracted instead of the total investment. This is a yardstick which is applicable to any economic balance, whether it be the decision to proceed with a project, the choice between alternatives, the design of equipment, or the shutdown of an existing operation. If a project has a positive incremental present worth, it will produce a greater profit, on the average, than that from the same capital invested in marginal projects. Of two or more mutually exclusive alternatives, the one having the highest incremental present worth is the most attractive. Other criteria are not always selective in this respect.

The Role of Profits

Capital may be used to purchase consumer goods and services, or producer goods. Consumer goods are food, clothing, shelter, and articles contributing to the pleasures of life. Producer goods are machines, structures, and facilities for development of natural resources used directly or indirectly to manufacture consumer goods.

Capital is obtained from profits, reserves, the sale of long term notes, equity financing and the sale of assets. An oil company recently built a large office building, sold it to an insurance company and then leased it in order to obtain capital for more profitable investments.

Profit is the driving force for investment of capital—without it, there is no incentive for investments. If the incentive is strong enough—if the anticipated reward or profit is large enough, the owner of the capital foregoes the immediate pleasure of consumer goods in exchange for an investment in producer goods. In 1948, the Flanders Committee investigated a popular assumption that business profits were too high. Industry spokesmen showed adequate reasons why this was not so. Mr. Coyle of General Motors summed up the industry position with these words: "The function of profits is to provide incentive and the means for progress. The hope of profits is the driving force of venture and enterprise. The realization of profits provides the seed corn for further growth."[2]

The advances brought about from industrial enterprise are shared by consumer, stockholder, and labor groups. The consumer gets his share from new and better products, or lower prices; the stockholder from dividends and stock appreciation; and the worker from higher wages, shorter working hours and other benefits.

Criteria for Investment of Capital

The basic incentive for the investment of capital is that the original amount of the investment plus a profit must be recovered during a definite time period in the future. The magnitude of the necessary profit varies with the supply of available capital and the demand for capital as represented by project opportunities. There is a minimum value of the required profit even though there is absolutely no risk involved.

There can be no argument that the proper criteria for the investment of capital are those which results in the greatest increase in company assets and accumulated profits, and which are consistent with policies of safety, conservation and good will.

The more frequently used criteria are:

- Payout time
- Incremental payout time
- Cash position
- Return on investment
- Capitalized costs
- Future worth
- Present worth
- Incremental present worth

The *incremental present worth*, properly computed, is applicable to any economic evaluation. This applies regardless of whether or not capital investment is involved. Some of the other mentioned criteria are not suitable except under limited conditions.

Payout time is frequently used in economic studies. The simplest definition is the capital invested in facilities divided by the anticipated average annual gross income before deducting income tax. This definition neglects too many important factors to be of practical significance.

Payout time on a basis after income tax is the capital invested in facilities divided by the income after deducting income tax. The statement that a project must show a payout time of five years to be attractive is equivalent to the statement that it must result in an income equal to the original capital investment during the first five years of operation and it implies that operation thereafter will result in a profit.

Table 1 shows the maximum allowable payout time for new equipment and buildings in certain industries as reported in a 1949 survey. A large percentage of the companies in each industry surveyed requires a payout time not to exceed 3 to 5 years on new equipment. A somewhat higher payout is permitted on buildings. The difference in maximum allowable payout of buildings over equipment may reflect the longer useful life anticipated for buildings.

The payout times shown in Table 1 may not be based on a uniform definition. Undoubtedly some of the values shown are based on investments inside battery limits and others are based on "total" investment.

TABLE 1
Survey on Maximum Allowable Payout Time*
Percent of Companies Replying

	Maximum Allowable Payout Time, Years				
	2 or Less	2 or 3	3 to 5	5 to 10	10 or More
New Equipment					
Steel	..	..	80	20	..
Automobile	29	28	15	15	13
Petroleum	..	..	50	50	..
Chemical	11	33	45	11	..
Buildings:					
Steel	..	..	35	65	..
Automobile	..	..	..	72	28
Petroleum	..	..	50	50	..
Chemical	..	..	57	14	29

* 1949 McGraw-Hill Survey.

Minimum Attractive Return. Payout time gives only a nebulous appraisal of an investment in a project. A more conventional method of expressing profits is return on investment.

Just as there is a maximum allowable payout time above which a given company is not willing to invest its capital, there is a corresponding minimum attractive return or marginal return rate below which capital will not be invested. An excellent discussion of minimum attractive return is given by Grant.[3]

The minimum attractive return rate is related to maximum allowable payout time by Equation 1. This equation is based on a depreciation base for income tax purposes equal to the expected number of years of operation. It neglects the construction period and assumes a negligible salvage value.

$$\frac{1}{\text{Payout after tax}} = \frac{m\,(1+m)^n}{(1+m)^n - 1} + \frac{mI_w}{I_f} \qquad (1)$$

Table 2 shows the relationship between maximum allowable payout time and minimum attractive return. This table shows that the payout time varies considerably with minimum attractive return rate and the period of operation. And it varies somewhat with the ratio of working to facility capital. Payout time is not a suitable yardstick for comparison of alternative projects. Incremental payout time can be used for this purpose however.

TABLE 2
Minimum Attractive Return Rate Vs. Maximum Allowable Payout Time

Minimum Attractive Return Rate	Period of Operation Years	Payout Time, Years: Ratio of Working to Facility Capital 0.25	Payout Time, Years: Ratio of Working to Facility Capital 0.50
0.05	5	4.1	3.9
0.05	10	7.0	6.5
0.05	15	9.2	8.2
0.10	5	3.5	3.2
0.10	10	5.3	4.7
0.10	15	6.4	5.5
0.15	5	3.0	2.7
0.15	10	4.2	3.6
0.15	15	4.8	4.1

In spite of its shortcomings, payout time after income tax is a very useful shortcut to an economic evaluation because of its simplicity. However, the value used in an economic study should be checked against the period of operation, the ratio of working capital to facility capital, and the applicable minimum attractive return rate.

Evaluation of Minimum Attractive Return. The minimum attractive return or marginal return rate used here is on a basis after income tax. It is the equivalent "interest" or return rate which gives the earning potential after taxes of marginal projects. It is a function of capital availability and project opportunities, and varies between companies due to differences in these factors.

At the end of each year a company will have available for reinvestment a certain amount of cash as determined by its profits, dividend policy, borrowing ability, etc. The company also may have developed a number of project opportunities ranging in attractiveness from very high to very low, say the equivalent in return rates from 30 percent to 2 percent. Suppose there were sufficient funds to go ahead with all projects. The average stockholder would certainly be opposed to an investment which returned only 2 percent because he could use the capital, paid to him as dividends, to better advantage in paying off the mortgage on his home or perhaps for investment in a savings account. For this situation, then, management might decide that no project would be undertaken which did not indicate at least 5 percent return on the investment, even if there were absolutely no risks involved.

Suppose that the capital supply were somewhat limited and the same project opportunities were available as above. The company would choose sequentially those projects showing the higher return rates. After the available funds were allocated on this basis the last few projects on the list might show a return rate of 10 per-

cent. This would be the minimum attractive return.

If even less capital were available, the projects showing return rates of perhaps less than 15 percent would have to be put on the shelf and 15 percent would be the minimum attractive return rate. Thus the supply of capital and the demand represented by project opportunities determine the minimum attractive return rate.

Obviously a time period of several years should be considered in evaluating the minimum attractive return rate. The rate used in an economic analysis should be the weighted average value which is anticipated to be in effect for the period of operation corresponding to the project. The minimum attractive return rate is always less than the average return rate for all investments.

Risk Considerations—There are few projects where the anticipated profit is a sure thing. Instead there are many risks which will dictate the ultimate outcome. Some are eliminated or greatly reduced as a normal matter of course. For example, spare pumps are provided for services which, if interrupted, would result in damage to other equipment or would cause a costly shutdown of the plant. Fire fighting equipment and other safeguards are also provided without question. Sometimes a risk may be transferred to others at a cost. For example, both a process warranty and guaranteed installed cost may be obtained for some projects usually at added cost.

A hazard which is easily recognized and which may be assigned a relatively accurate cost usually is considered not as a risk but rather as a normal cost of operation. Fire, explosion, and public liability insurance are examples. During the time before insurance companies were formed, fire hazard was a risk in another sense of the word and was a strong deterrent to the investment of capital.

Risks may be reduced by investing money to develop better information by research and development, small scale production, market analysis and detailed engineering studies. The costs and delays involved must be balanced against the competitive advantage of being first in the market and against the immediate prospect of profits but essentially represent insurance against large scale failures.

There is appreciable controversy over the proper manner to evaluate risk in an economic appraisal. Frequently it is overlooked entirely or considered in an abstract manner.

How is risk evaluated? Happel and Aires[6] suggest a high marginal return rate be used with high risk projects. It is true that the use of a high marginal return rate results in a stiff penalty to a project. However, the method is not sound. Requiring a high marginal return rate implies that the estimate is known to be biased. Choosing the proper minimum attractive return rate is one of opinion and the risk is not assigned to the proper element of the estimate where it may be viewed objectively.

There are two general types of risk.

1. That of complete failure due to process or other reasons. This may result from the inability to obtain raw materials, the enactment of a new law, loss of market, process reasons or other factors. After the investment is made and the failure is recognized, the project is shutdown and salvaged.

2. That of partial success. The profit from these projects may be less than anticipated and may even be so low that the original investment will never be recovered. However, the plant is kept on stream, even though an additional investment is sometimes necessary, because the alternative of shutting down is less attractive than continued operation. Consider for the moment only those risks associated with partial success.

Evaluating a risk accurately can only be done when there is a great deal of past experience from which probabilities of an ocurrence may be determined. An example is the risk of fire and explosion for which the probabilities are well known for particular installations. Protection for a time interval may be obtained for such hazards from insurance companies.

Assign Values to Risks. Why shouldn't other risks be considered in the same light? That is, assign the cost of the risk to that element of an economic analysis to which it belongs. The cost of risk associated with the process would be assigned to the investment in facilities. Those associated with working capital would be assigned to working capital and those associated with various items comprising gross income would be assigned to revenue or operating costs. A check list could be used to prevent overlooking a potential major risk. Lasser[11] gives a list of risks which should be considered.

Estimating Precision. There is a variable degree of uncertainty in the estimation of many of the items of an economic analysis. The ability of the group responsible for estimating the elements of an economic appraisal is a big factor in the risk associated with a particular project. A recent paper by Tielrooy[12] stresses some of the capital costs which should not be overlooked by an estimating group. If the group has had adequate experience in a particular field, and continually strives to improve its techniques, the reliability of its estimates in that field may be very good.

Even though its techniques are excellent, if an important process step has been incorrectly designed or improper materials of construction are chosen, the estimate will not reflect the additional investment necessary to make the process operable. Additional capital expenditures are far more likely to be necessary for new unproven processes or unusual scale-up problems than for well established processes. This analogy obviously can be applied to other elements of an economic analysis.

Contingency Factors. The reliability of the estimate of individual items comprising an economic analysis could be improved by use of contingency factors to reflect past experience. The investment estimated by an established procedure would be multiplied by a factor of unity for additions to existing plants and for proven processes having no unusual scale-up problems. New process involving no unusual scale-up considerations would have a contingency factor somewhat higher than unity. Unproven processes with unusual scale-up problems would have an even higher contingency.

It is quite possible that the anticipated income would be in doubt for a particular project whereas the estimate of capital investment would be on firm ground. Or, both the gross income and capital investment might have risk potentials. Contingency factors could be determined for a firm in a particular field by plotting the ratio of esti-

mated to actual capital investment for project classifications such as:

- Additions to existing plants
- Ground-up installations of established processes
- New processes, etc.

Scale-up problems and source of information should also be considered in classifying projects. The same could be done to develop contingency factors for sales realization and operating expenses. Table 3 shows hypothetical contingency factors which might be evaluated for a company on this basis.

TABLE 3
Contingency Factors for Risk Evaluation*

	Cost of Installation		Operating Costs	
	Scale-Up Problems		Scale-Up Problems	
	None	Unusual	None	Unusual
Established Processes:				
Additions	1.0	1.1	1.0	1.1
Ground-Up	1.0	1.2	1.0	1.2
New Process, Allied Field:				
Pilot Plant Experience	1.2	1.5	1.2	1.3
Bench Scale Experiments	2.0	3.0	1.5	2.0
New Process, New Field:				
Pilot Plant Experience	2.0	3.0	1.5	2.5
Bench Scale Experiments	4.0	10.0	3.0	5.0

*These factors are for illustrative purposes only.

The point being made here is that risk considerations should be applied to individual elements of an economic appraisal. By this means each item will reflect the most probable value and, on the average, estimated and actual values will correspond. On this basis the minimum attractive return rate is independent of risk. It is a function only of the relative supply and demand for capital.

Elements of an Economic Analysis

The various items comprising an economic analysis are—

• **Sales Realization** is the anticipated annual revenue from the sale of products and services. Under some conditions a portion of the revenue from sales of minerals, i.e., the depletion allowance, is exempt from income tax. Revenue may increase, decrease or remain constant during the life of the project.

• **Operating Costs** include the cost of raw materials, utilities, services, transportation, royalty, wages and salaries, social security and unemployment taxes, labor benefit costs, direct overhead, and so on. Direct overhead includes those costs which are incurred at the head office as the result of the project. Some items of cost are directly proportional to sales; others may be independent of sales.

• **Capital Investment** is the tangible and intangible investment in facilities and working capital. The tangible investment is the installed cost of those items of equipment which are subject to depreciation over a period of years for income tax purposes. This might include a lump sum royalty or patent rights.

The useful life of individual pieces of equipment may be less than that of the project as a whole and such equipment will have to be replaced one or more times during the life of the project; thus future recurring capital investments may be involved.

The intangible investment or "start-up expense" is the cost of getting the project on its feet prior to commercial operation and that portion of the investment in facilities which may be deducted, for income tax purposes, from current income during the year it is spent. Tielrooy[12] refers to construction expense as "pre-profit" expense. The intangible investment may be capitalized and depreciated over a number of years if desired.

Working capital is used here as all other capital required to operate the project on which depreciation is not allowed for income tax purposes. It includes the money tied up in raw materials, intermediate and finished products both in transit and in storage, accounts receivable, the cost of land and other capital of a similar nature. Working capital may be recovered at the end of the period of operation but there are certain costs associated with it. Ordinarily, the cost of land is not thought of as working capital. It is so considered here because its effect on investment decisions is the same as working capital.

• **Capital Charges** are costs which are proportional to the investment. Maintenance, preventative maintenance, ad valorem tax and fire insurance are associated with tangible investment. Losses from bad debts and spoilage, ad valorem tax on land assessment and inventories, and similar costs are associated with working capital.

• **Income Tax Rate** is the sum of state and federal income tax rates. The rate increases with increased earnings up to a point. The rate for corporation profits over a certain minimum amount has hovered near the 50 percent mark for a number of years. The federal tax rate during times of war has been as high as 85 percent on "excess profits." The tax rate which is anticipated to be in effect on incremental earnings should be used in an economic study.

• **Depreciation Schedule** is that schedule of depreciation rates allowed by law which is to the greatest advantage of the corporation. "Bulletin F" available at the Government Printing Office may be used as a guide to the useful life of many assets. An accelerated depreciation rate for tax purposes, permitting a much faster write-off than normal, has been allowed for defense industry projects in the past.

There are several depreciation schedules which may be used: the straight line, declining balance, sum of year's digits, and combination. The best method depends on circumstances of the company's future earnings, i.e., tax bracket, and anticipated changes in income tax rate.[1] For example, if the applicable income tax rate is anticipated to decline, a fast write-off should be used; if the tax rate is expected to increase, a slow write-off may be most advantageous. Happel[7] gives equations for choosing the best of the various methods for the case of constant tax rate. However, the anticipated *change* in applicable tax rate may be the primary factor in determining the best method; this applies especially for companies whose earnings are such that higher tax brackets in future years are anticipated.

• **Period of Operation** is the anticipated number of years of operation before the project is shutdown from

any cause except that of complete failure. An estimate which is neither deliberately optimistic nor conservative, should be used. It effects the decision on whether or not the investment should be made and also, the design of individual pieces of equipment.

• **Salvage Value** is the estimated value of the equipment above the cost to dismantle and restore the site. It may be either negative or positive. Usually, it can be neglected but it might be an important consideration where an immediate salvage operation is being compared to an alternative.

• **Marginal Return Rate** or minimum acceptable return rate is that corresponding to marginal projects. The method for determining this value has been discussed at length in the first part of this article.

• **Probability of Complete Failure** is an important consideration for some projects. Oil well drilling is an example. The probability of complete failure depends on local circumstances but may be 0.9 or more for wildcat wells. Complete failure is always a factor to be considered for unproven processes. The probability of complete failure can be estimated from past experience if sufficient data are available for various type projects.

• **Contingency Factors** have been discussed in an earlier section of this article. Each item of an economic analysis should be adjusted to have the most likely value taking scale-up, etc., into consideration. The function of contingency factors is to reduce the bias of an estimate.

Incremental Present Worth

The present worth of a project is the accumulated future profits and tax credits reinvested as received at the marginal return rate plus the value of salvage and working capital at the projected end of the operation, all expressed in terms of present value as of the date the capital is committed. The *incremental present worth* of a project is the present worth *minus* the total investment required. Thus the incremental present worth of a project is a measure of the *increase* in value of assets and accumulated profits above that which would be obtained if the capital were invested in marginal projects.

The incremental present worth of a project changes as construction proceeds and the project becomes an installation. Past expenditures and past revenue are not given consideration after construction is completed or at any time during operation. After the investment is made and at any time during operation, the present worth is the accumulated future profits and future tax credits reinvested at the marginal return rate plus the value of salvage and working capital available at the projected end of the operation, all expressed in terms of present value as of the immediate date. The incremental present worth of an installation is its present worth *minus* the immediate value of salvage, working capital and tax credits which would be available if the project were discontinued immediately. Thus the incremental present worth of an installation is a measure of the increase in value of assets and accumulated profits above that which would be obtained if the plant were shut down and the capital obtained were invested in marginal projects.

Values of incremental present worth which are negative, zero and positive correspond to projects, or projected operations of installations, which are sub-marginal, marginal and above marginal, respectively. In a comparison of mutually exclusive projects, or alternatives, the one having the highest incremental present worth is the most attractive. The incremental present worth of an installation will decrease as the remaining years of operation decline. The installation should be shutdown and salvaged when the incremental present worth dips below zero unless some alternative usage having a positive worth can be found. Krase[10] discusses some of the aspects of discontinuing an operation.

The following equation expresses the present worth of the taxable portion of sales realization:

$$\text{present worth} = \frac{R_1 (1 - t_1)}{(1 + m)^{1+c}} + \frac{R_2 (1 - t_2)}{(1 + m)^{2+c}} + \cdots + \frac{R_n (1 - t_n)}{(1 + m)^{n+c}} \qquad (2)$$

where

R_1, R_2 = sales realization during 1st, 2nd, . . . year after commercial operation, dollars/year
t_1, t_2 = applicable income tax rate, fraction/year
c = time in years between the start of construction (commitment of capital) and commercial operation
n = number of years of operation; subscript n refers to nth year

If the tax rate and sales realization are assumed uniform from one year to the next, Equation 2 may be written:

$$\text{present worth} = R (1 - t) \frac{(1 + m)^n - 1}{m (1 + m)^{n+c}} \qquad (3)$$

Present worth equations may be developed for other items of an economic study which are uniform or progress in an orderly fashion. Several such equations are given in the appendix.

It is not likely that many of the recurring items of an economic study will remain uniform throughout the life of the project; however, in order to examine the effect of the risk of complete failure on design and selection of alternatives, an equation based on uniform recurring items will be written. The incremental present worth of a project as a success, W_s, based on uniform sales realization, operating expenses, income tax rate, etc., and a depreciation rate on the tangible investment which is uniform but not necessarily based on the period of operation is given below. It is the present worth of tax exempt revenue, taxable revenue and operating expense,

$$W_s = [R_s F_n + (R_t - E)(1 - t) F_n]$$

minus the present worths of capital charges on recurring investments, initial tangible investment, and working capital,

$$- (1 - t) F_n \Sigma (I_r k_r + I_s k_s + I_w k_w)$$

plus the present worths of the lump sum income tax credit on the intangible investment, the annual tax credit on capital investments which recur at intervals, the annual tax credit on investment in assets with an accelerated depreciation rate, and the annual and lump sum tax credits on investment in assets with a retarded depreciation rate,

$$+ I_i t + \sum_{n>r} \frac{I_r t F_n}{r} + \sum_{n>d} \frac{I_s t F_d}{d} + \sum_{n \le d} \frac{I_s t}{d} \left(F_n + \frac{d - n}{(1 + m)^n} \right)$$

plus the present worths of working capital and salvage value available at the end of the period of operation,

$$W_s = \underbrace{\left[R_e F_n + (R_t - E)(1-t) F_n - (1-t) F_n \sum (I_r k_r + I_a k_a + I_w k_w)\right]}_{\text{EQUALS}} + \underbrace{I_c t + \sum_{n>r} \frac{I_r t F_n}{r} + \sum_{n>d} \frac{I_a t F_d}{d} + \sum_{n \le d} \frac{I_a t}{d}\left(F_n + \frac{d-n}{(1+m)^n}\right)}_{\text{PLUS}}$$

EQUALS — Tax exempt revenue; Taxable revenue; Operating expense

MINUS — Present worths of capital charges on recurring investments. Investment in assets; Working capital

PLUS — Present worths of the lump sum income tax credit on the intangible investment. Annual tax credit on capital investments which recur at intervals. Annual tax credit on investment in assets with an accelerated depreciation rate. Annual and lump sum tax credits on investment in assets with a retarded depreciation rate.

The incremental present worth of a project as a success.

$$+ \frac{I_w + S_n (1-t)}{(1+m)^n}\left]\left[\frac{1}{(1+m)^e}\right]\right.$$

minus the total investment to be made initially in facilities and working capital and minus the present worth of future recurring investments,

$$-(I_e + I_r + I_a + I_w) - \sum_{n>r} I_r F_r/(1+m)^e \qquad (4)$$

where $$F_a = \frac{(1+m)^n - 1}{m(1+m)^n} \qquad (5)$$

$$F_d = \frac{(1+m)^d - 1}{m(1+m)^d} \qquad (6)$$

$$F_r = \left[\frac{(1+m)^n - 1}{m(1+m)^n}\right]\left[\frac{m(1+m)^r}{(1+m)^r - 1}\right] - 1 \qquad (7)$$

r = life of recurring individual asset having a useful life less than the period of operation

d = life of non-recurring asset allowed for depreciation, years

Equation 4 is based on certain assumptions as follows:

1. That the income, after tax, is available for reinvestment at the end of each year of operation whereas it may be available continuously throughout the year;

2. That all capital required for the project is committed (not available for other purposes) at the beginning of the construction period whereas it may be committed continuously during construction;

3. That revenue, expenses, and annual tax credits are uniform from year to year. Some of the terms included in the equation may not necessarily apply to all evaluations. Tax exempt revenue is an example.

TABLE 4

Present Worth Factor of a Uniform Annual Series

Years of Operation	Present Worth Factors — Minimum Attractive Return, m							
	0.5	0.06	0.07	0.08	0.09	0.10	0.15	0.20
5	4.33	4.21	4.10	3.99	3.89	3.79	3.35	2.99
6	5.08	4.92	4.77	4.62	4.49	4.36	3.78	3.33
7	5.79	5.58	5.39	5.21	5.03	4.87	4.16	3.60
8	6.46	6.21	5.97	5.75	5.53	5.33	4.49	3.84
9	7.11	6.80	6.52	6.25	6.00	5.76	4.77	4.03
10	7.72	7.36	7.02	6.71	6.42	6.14	5.02	4.19
12	8.86	8.38	7.94	7.54	7.16	6.81	5.42	4.44
14	9.90	9.29	8.75	8.24	7.79	7.37	5.72	4.61
16	10.84	10.11	9.45	8.85	8.31	7.82	5.95	4.73
18	11.69	10.83	10.06	9.37	8.76	8.20	6.13	4.81
20	12.46	11.47	10.60	9.82	9.14	8.51	6.26	4.86

Worth Factors. Present worth factors which are not necessarily uniform but progress in a regular manner, may be substituted in Equation 4. For example, if the sales realization is expected to decrease each year by a constant percentage of the previous year's value, the present worth factor given by Equation 20 in the Appendix would apply. Values of present worth factors based on a uniform annual series are given in Table 4.

An approximate value of the present worth factor of a uniform annual series for values of m between 0.05 and 0.15 and values of n between 5 and 15 years is as follows:

$$F_a = \frac{(1+m)^n - 1}{m(1+m)^n} \simeq \frac{1}{.63m + 1/n}$$

Example 1. A major project is being evaluated for a projected life of 15 years. The estimated sales realization is \$8,660,000 and operating costs exclusive of capital charges are \$4 million each year. The tangible investment is \$11 million on which the weighted average capital charges rate is 0.12. A "Certificate of Necessity" has been obtained on the tangible investment, allowing a uniform depreciation over a five-year period. The income tax rate is 0.52. The intangible investment is \$2 million. Working capital is \$3 million on which the average capital charges rate is 0.04. Salvage value is \$600,000. The construction period is two years. All items have been adjusted by applicable contingency factors. What is the incremental present worth as a success based on a minimum attractive return rate of 0.08?

$$\frac{W_s}{10^6}\Big\} = [8.66 - 4.0 - (11)(0.12) - (3)(0.04)][0.48]\left[\frac{(1.08)^{15} - 1}{(0.08)(1.08)^{15}}\right]$$

$$+ (2)(0.52) + \left[\frac{(11)(0.52)}{5}\right]\left[\frac{(1.08)^5 - 1}{(0.08)(1.08)^5}\right.$$

$$+ \frac{3 + (0.6)(0.48)}{(1.08)^{15}}\Big\}\Big\{\frac{1}{(1.08)^2}\Big\{ - (2 + 11 + 3)$$

$$= [(1.55)(8.55) + 1.04 + (1.14)(3.99) + 3.29/3.17]/1.17 - 16$$

$$W_s = [(13.2 + 1.04 + 4.55 + 1.04)/1.17 - 16][10^6]$$

$$= [(19.85/1.17) - 16][10^6] = \$1{,}000{,}000$$

This corresponds to an above-marginal project because

$$+\left[\frac{I_w+S_n(1-t)}{(1+m)^n}\right]\left[\frac{1}{(1+m)^c}\right]-(I_c+I_r+I_a+I_w)-\sum_{n>r}\frac{I_r F_r}{(1+m)^c}$$

PLUS — Present worths of working capital and salvage value available at the end of the period of operation.

MINUS — Total investment to be made initially in facilities and working capital.

MINUS — Present worth of future recurring investments.

the incremental present worth is positive. The potential earnings from the project in terms of present worth are $1 million greater than that which would be obtained if the $16 million capital requirement were invested in marginal projects.

Example 2. Same as Example 1 except the sales realization is $8.1 million each year. What is the incremental present worth as a success?

$$W_s = 1{,}000{,}000 - (8.66 - 8.1)\ (0.48)\left(\frac{(1.08)^{15}-1}{(0.08)\ (1.08)^{15}}\right)(10^6)$$

$$= 1{,}000{,}000 - 1{,}970{,}000 = -\$970{,}000$$

Example 3. Same as example 1 except the construction period (time between commitment of capital and start up) is four years. What is the incremental present worth as a success?

$$W_s = \left[\frac{19.85}{(1.08)^4} - 16\right](10^6)$$

$$= -\$1{,}400{,}000$$

Examples 2 and 3 show negative answers and the project should be cancelled. However, another estimate may be justified. See the section on *Economics of Cost Estimating*.

Example 4. A valuable product can be shipped by rail at total cost of $5000 per year. The value of the inventory in transit is $100,000. If shipped by motor freight, the cost is $20,000 per year but the value of inventory in transit is only $30,000. The marginal return rate is 0.15, the tax rate is 0.52 and a three-year period of operation is contemplated. How should the product be shipped?

$$W(\text{rail freight}) = -(5000)\ (0.48)\left(\frac{(1.15)^3-1}{(0.15)\ (1.15)^3}\right)$$

$$+\frac{100{,}000}{(1.15)^3} - 100{,}000 = -\$39{,}300$$

$$W(\text{motor freight}) = -(20{,}000)\ (0.48)\left(\frac{(1.15)^3-1}{(0.15)\ (1.15)^3}\right)$$

$$+\frac{30{,}000}{(1.15)^3} - 30{,}000 = -\$32{,}000$$

It is better to ship by motor freight even though the shipping charges are greater. The opposite conclusion would be obtained if the marginal return rate were less than about 10 percent.

Existing Installations. The incremental present worth of an existing installation is defined in the second paragraph of this section. The equation is as follows:

$$W = (R - E)\ (1-t)F_n - (I_r k_r + I_r k_a + I_w k_w)\ (1-t)F_n$$

$$+ \text{present worth of remaining annual tax credits}$$

$$+\frac{I_w + S_n\ (1-t)}{(1+m)^n}$$

$$- \text{present worth of future capital investments}$$

$$-[I_w + S_n\ (1-t) + \text{lump-sum value of remaining tax credits}] \qquad (8)$$

where n = the remaining number of years of operation.

Example 5. The project described in Example 1 has been completed and has started operating. No tax credits have been obtained. The immediate salvage value is $2.5 million. What is the incremental present worth?

$$W_s = \{19.85 - [(2.5)\ (0.48) + 3 + (2 + 11)\ (0.52)]\}\{10^6\}$$

$$= \$8{,}840{,}000$$

Example 6. The gross income from an existing operation is $50,000 per year. All tax credits have been obtained. The working capital is $300,000 and the immediate salvage value is $100,000. It is estimated that the operation can be continued for only five years at which time the salvage value will be $60,000. The marginal return rate is 0.10 and the tax rate is 0.35. Should the operation be continued or should it be shut down immediately?

$$W = (50{,}000)\ (0.65)\frac{(1.10)^5-1}{0.10\ (1.10)^5} + \frac{(60{,}000)\ (0.65) + 300{,}000}{(1.10)^5}$$

$$- (100{,}000)\ (0.65) - 300{,}000$$

$$= 123{,}000 + 211{,}000 - 365{,}000 = -\$31{,}000$$

Since the incremental present worth of continued operation is negative, the plant should be shut down now. In effect, the earning potential of the working capital and immediate salvage value, invested in marginal projects, is more than that of continued operation.

Projects Having Risk of Complete Failure. The incremental present worth of a project as a complete failure is:

$$W_f = \frac{(I_c + I_r + I_a)t + I_w + S_n\ (1-t)}{(1+m)^c} - (I_c + I_r + I_a + I_w) \qquad (9)$$

where S_n = the salvage value on complete failure.

The incremental present worth of a project having a known probability of complete failure, ρ_f, is its worth as a success times the probability of success plus its worth as a failure times the probability of failure:

$$W = W_s\ (1 - \rho_f) + W_f \rho_f \qquad (10)$$

Projects involving new processes, even though "proven" by pilot plant experience, sometimes fail. The evaluation of the probability of failure for various type projects must be based on experience.

Example 7. A project having a very high risk of complete failure is being evaluated. Its incremental present worth will be $200,000 if a success and minus $100,000

if a failure. The probability of failure is 0.80. What is the incremental present worth?

$$W = (0.2)\ (200{,}000) + (0.8)\ (-100{,}000) = -\$40{,}000$$

Example 8. The example above indicates a negative incremental present worth. Should the project be carried forward if there are five additional identical projects which could be installed if the first one is successful?

$$W_1 = (0.2)\ (6)\ (200{,}000) + (0.8)\ (-100{,}000) = \$160{,}000$$

The answer is yes. Even though the chances are great that a loss will be incurred on the first unit, the potential from additional units indicates a gain.

Economics of Cost Estimating and Research. The preceding sections of this article develop the incremental present worth as a criterion for making investment decisions. The reliability of the information used in calculating the criterion is also a factor to be considered.

Large corporations may have two or more cost estimating porcedures which are used as the occasion demands. A short-cut procedure is usually used in the preliminary stages of evaluating any project. A detailed procedure is used when a more reliable value of the incremental present worth can be justified.

Short-cut estimating procedures are less accurate than detailed procedures and one is less likely to make a wrong decision using a detailed procedure. However, the added cost should be weighed against the potential gain before proceeding. In effect, making a detailed cost estimate is a "project" which should not be undertaken unless a positive incremental present worth is shown.

Standard Deviation. If the incremental present worth of a project divided by the standard deviation of the estimating procedure is greater than about ± 2.0, there usually is little incentive to justify a more detailed estimate. However, as the ratio approaches zero from a positive value, there is an increasing probability that the project actually may be a partial failure; that is, it may be sub-marginal or have an actual incremental present worth which is negative. Similarly, as the ratio approaches zero from the negative side, there is an increasing probability that the project actually may be better than marginal and if cancelled, would result in lost profits.

The procedure by which a decision is reached as to whether or not a detailed estimate is justified has been published by Hicks and Steffens.[8] The formal mathematics backing this procedure were developed by Grundy, Rees and Healy[4,5] and independently, by L. R. Steffens.

The standard deviation of an estimate is a measure of the scatter or distribution of values about a mean. The deviation is a function of the time and effort placed in the estimate and also the reliability of the information used in preparing the estimate. The contingency factors discussed earlier in this paper are used to reduce the bias of an estimate. However, it is axiomatic that high contingency factors also involve high standard deviations.

Detailed Estimate. The reliability of an estimate can be improved by use of more elaborate estimating procedures and/or by investing money in research and development, market analyses, consultants, etc. The result of such actions reduces the standard deviation of the estimate. The following procedure may be used to decide when a detailed estimate is justified:

1. Calculate the incremental present worth of a project using a short-cut estimating procedure, but giving consideration to all important factors.
2. Determine the standard deviations of the short-cut and detailed estimating procedures for conditions corresponding to the project. Correlations of standard deviations for various classifications of information must be developed from company experience for this purpose.
3. Calculate the ratio of detailed to short-cut standard deviations. Calculate the ratio of incremental present worth to short-cut standard deviation.
4. Determine the ratio of expected gain to standard deviation of the short-cut estimating procedures from Figure 1.
5. Multiply the result from step 4 by the short-cut standard deviation and deduct the sum of all costs and other penalties to be incurred in making an estimate by the detailed procedure.
6. If the result from step 5 is positive, the detailed estimate should be made. If the result from step 5 is negative, the incremental present worth from step 1 should be used to decide whether or not the project is to be installed.

An analogous procedure may be used to decide when more reliable design information should be obtained. For this case, the standard deviation of the information used in preparing the estimate is substituted in the above procedure for the "short-cut" deviation, the standard deviation of the additional information is substituted for the "detailed" deviation and the cost of obtaining the additional information is substituted for cost of the estimate. Although a substantial effort may be required to obtain correlations of standard deviations, and keep them up to date, the potential earnings from such a project probably would be substantial for larger corporations.

It should be noted that the above method is applicable only when the estimates by the two methods are entirely independent. When the estimates are partly independent and partly dependent, the method is not applicable. The procedure for handling the latter situation will be published at some future date.

Example 9. The incremental present worth of a project by a short-cut estimating procedure is —$40,000. The standard deviation of the short-cut procedure is $100,000 in terms of incremental present worth for conditions corresponding to the magnitude of the project. A detailed estimate having a standard deviation of $20,000 can be obtained at a cost of $10,000. The income tax rate is 0.52. Should the detailed estimate be made?

$$\frac{\text{Standard deviation, detailed estimate}}{\text{Standard deviation, short-cut estimate}} = 0.20$$

$$\frac{\text{Incremental present worth, short-cut estimate}}{\text{Standard deviation, short-cut estimate}} = -0.4$$

$$\frac{\text{Expected gain} + \text{cost of detailed estimate}}{\text{Standard deviation, short-cut estimate}} = 0.22 \text{ (Figure 1)}$$

$$\text{Expected gain} = (0.22)\ (100{,}000) - (10{,}000)\ (1 - 0.52) = \$17{,}000$$

The detailed estimate should be made because the expected gain is positive. In effect, the margin for error

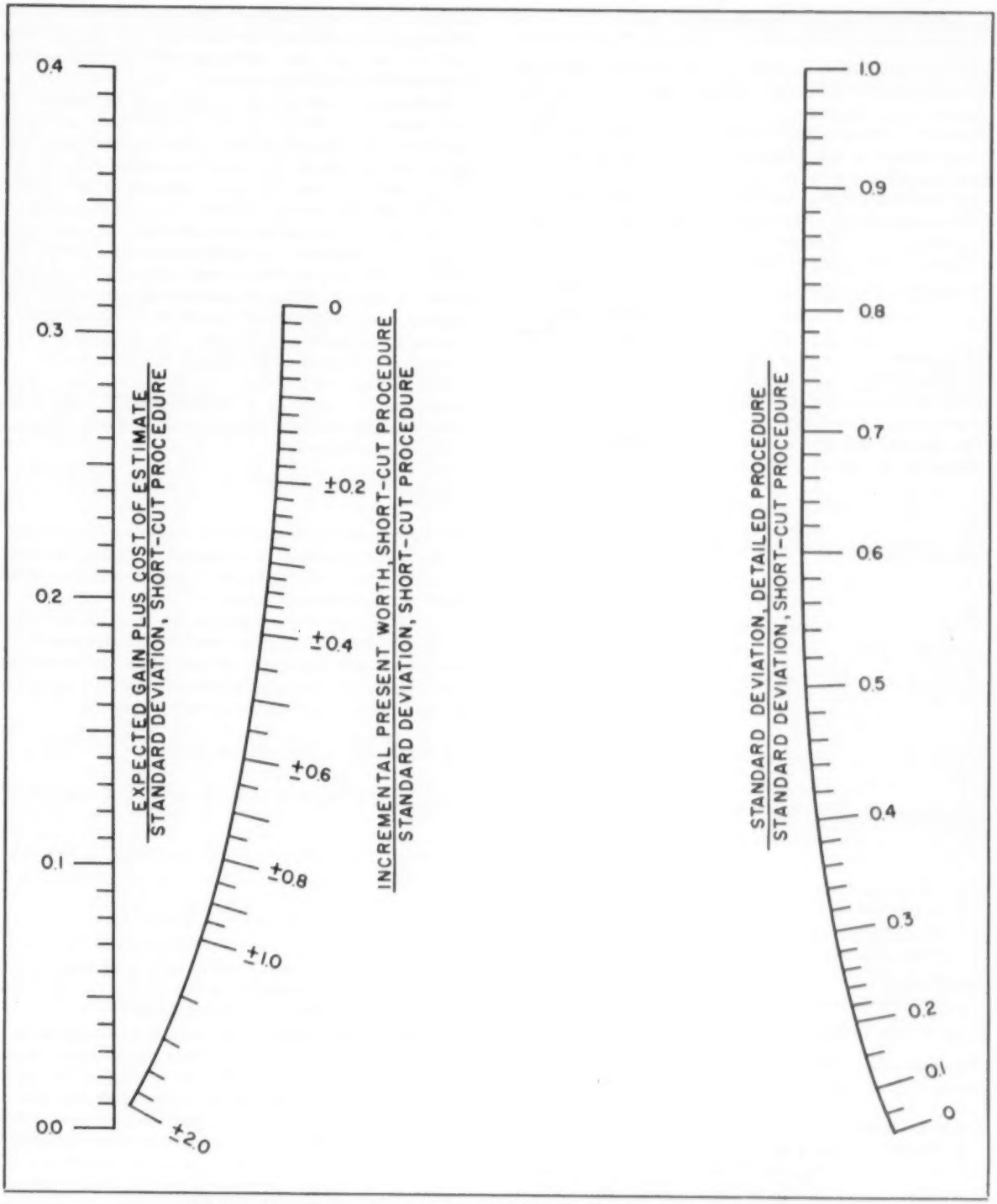

FIGURE 1—Nomograph to determine expected gain for justification of a detailed estimate.

using the short-cut procedure is so large, relatively, that the chances are good that the project could have a positive incremental present worth. The probabilities are such that the cost of the detailed estimate is justified. The same result would have been obtained if the incremental present worth had been +$40,000. If the incremental present worth by the short-cut method had been less than —$130,000 or greater than +$130,000, the detailed estimate could not have been justified.

Example 10. The incremental present worth of the

project described in Example 1 is $1 million. This value was obtained by a detailed estimate based on data from a small pilot plant. Certain rather major scale-up problems are involved in the commercial size plant and it has been decided to investigate the advisability of installing and operating a semi-works plant prior to the commercial installation. The cost of obtaining the additional information after tax is $600,000. Correlations of standard deviations (from the company's past experience for projects of this nature) indicate the following:

	Standard Deviation, Percent		
	Amount $	Pilot Plant	Semi-Works
Sales Realization	8,660,000	10	5
Operating Expense	4,000,000	20	10
Intangible Investment	2,000,000	30	15
Tangible Investment	11,000,000	20	7
Working Capital	3,000,000	5	4

The incremental present worth of the project may be written as follows by collecting terms of Equation 4.

$$\frac{W_s}{10^6} = 3.52R - 3.52E - 0.55I_c - 1.06I_s - .87I_w$$

For example the multiplier of R is

$$(1 - 0.52)\left(\frac{(1.08)^{15} - 1}{0.08\,(1.08)^{15}}\right)\left(\frac{1}{(1.08)^2}\right) = 3.52$$

The standard deviation for the project as a whole using pilot plant data is calculated as follows:

$$\begin{aligned}(\text{Std. dev. Pilot plant}) &= \{[(3.52)(8.66)(0.1)]^2 + [(3.52)(4.0)(0.2)]^2 \\ &+ [(0.55)(2.0)(0.3)]^2 + [(1.06)(11)(0.2)]^2 \\ &+ [(0.87)(3.0)(0.05)]^2\}^{1/2}\{10^6\} \\ &= \$4{,}770{,}000\end{aligned}$$

The standard deviation for the project using semi-works data is:

$$\begin{aligned}(\text{Std. Dev. Semi-works}) &= \{[(3.52)(8.66)(0.05)]^2 + [(3.52)(4.0)(0.1)]^2 \\ &+ [(0.55)(2.0)(0.15)]^2 + [(1.06)(11)(0.07)]^2 \\ &+ [(0.87)(3.0)(10.04)]^2\}^{1/2}\{10^6\} \\ &= \$2{,}240{,}000\end{aligned}$$

$$\frac{\text{Standard deviation, semi-works}}{\text{Standard deviation, pilot plant}} = \frac{2.24}{4.77} = 0.47$$

$$\frac{\text{Incremental present worth, pilot plant}}{\text{Standard deviation, pilot plant}} = \frac{1.0}{4.77} = 0.21$$

$$\frac{\text{Expected gain} + \text{cost of additional information}}{\text{Standard deviation, pilot plant}} = 0.265 \text{ (Figure 1)}$$

$$\text{Expected gain} = (0.265)(4{,}770{,}000) - 600{,}000 = \$660{,}000$$

The semi-works data should be obtained because the expected gain is positive.

Other Criteria

Capitalized Costs. There are some who advocate capitalized costs for economic evaluations. The capitalized cost of an annual expense is simply the present worth of the expense based on the assumption it will be incurred each year from now to infinity. Similarly, the capitalized cost of an investment in equipment is the first cost plus the present worth of an infinite number of renewals to be made as the equipment wears out.

Jelen[9] suggests that capitalized costs can be used to select the best of two or more mutually exclusive alternatives. However, since the assumption of the "forever" time base is not realistic, erroneous conclusions for some problems can be obtained using the method. Jelen's method does not allow for the effect of income taxes and this too can give misleading results. This is illustrated in the following example.

Example 11. A tank with a negligible immediate salvage value can be kept in service for three additional years with an expenditure for repairs of $3000 now, and $1000 during each of the second and third years. At the end of the third year the tank will have to be replaced with a new one costing $15,000. The service provided by the tanks is needed for only 10 years. The new tank could be installed now as an alternative to repairing the old tank. The new tank will need no repairs during the period of service and will have no salvage value. The minimum acceptable return rate is 0.08. Should the replacement be made now or after the third year? This example is analogous to Example 9 in Jelen's article.[9]

This problem will first be solved for the case where income tax is neglected as done by Jelen. The incremental present worth of repairing the tank and replacing it after the third year:

$$-3000 - 1000/1.08 - 1000/(1.08)^2 - 15{,}000/(1.08)^2 = -\$16{,}700$$

The incremental present worth of replacing the tank now is —$15,000. Therefore, it would pay to replace the tank at once. The use of capitalized costs as given by Jelen shows the opposite conclusion.

It is interesting to examine the effect of income taxes on this problem. Using a tax rate of 0.52 and a uniform depreciation rate based on a 20 year period and a salvage value of zero, the incremental present worth of repairing the tank for three year's use prior to replacing it is:

$$-\left(3000 + \frac{1000}{1.08} + \frac{1000}{(1.08)^2}\right)(0.48) + \left(\frac{(15{,}000)(0.52)}{20}\right)$$
$$\left(\frac{(1.08)^7 - 1}{0.08\,(1.08)^7} + \frac{20 - 7}{(1.08)^7}\right)\left(\frac{1}{(1.08)^2}\right) - \frac{15{,}000}{(1.08)^2} = -\$10{,}250$$

The incremental present worth of replacing the tank immediately is:

$$\left(\frac{(15{,}000)(0.52)}{20}\right)\left(\frac{(1.08)^{10} - 1}{0.08\,(1.08)^{10}} + \frac{20 - 10}{(1.08)^{10}}\right) - 15{,}000 = -\$10{,}580$$

Thus, the effect of income tax for the conditions stated is to make it more desirable to repair and use the tank for three years use prior to replacement.

Return on Investment. The average return on investment is that interest rate which when compounded annually for the period of operation and applied to the original investment will equal the future worth of the profits and tax credits, etc., all reinvested as received at the marginal return rate. It may be calculated by the following equation:

$$i = (1 + m)(1 + W/I)^{1/n} - 1 \qquad (11)$$

It may be seen from this equation that the return rate corresponding to a marginal project, that is, a project having an incremental present worth of zero, is the minimum attractive return rate. The return on investment will be greater than the minimum attractive return for projects having a positive incremental present worth and vice versa.

The return on investment cannot be used to choose

the best of several alternatives; however, it is a useful criterion to judge the relative attractiveness of a project compared to marginal projects.

Weaver and Reilly[13] describes a trial and error method for calculating the "absolute rate of earnings" on capital invested. The "return" as calculated by their method assumes that profits are reinvested at the *average* return rate for the project. This assumption is contrary to the more realistic concept that profits are reinvested at the marginal return rate. The proper way to calculate return on investment is illustrated below.

Example 12. The incremental present worth of a project is $1000, the total investment is $5000, the period of operation is ten years and the marginal return rate is 0.10. What is the return on investment?

$$i = (1.10)(1 + 1000/5000)^{1/10} - 1 = 0.12$$

Optimum Economic Design

Profits originate from investments of capital in projects. Maximum profits accrue when each existing project is operated at its optimum in conjunction with other projects and when new capital is invested at its optimum as it becomes available.

Optimum operation of an existing facility is that which results in the maximum net profit per unit of time. Studies of the operation of an existing facility do not involve consideration of equipment design or capital expenditure.

The optimum investment of capital involves the choice of the best of the several alternative processes for accomplishing an objective, and the optimum process design or sizing of the equipment. Increasing the size of a piece of equipment generally increases the recovery of a product or reduces an operating expense, either of which will increase profits. However, the profit does not increase linearly with increasing investment but rather, the increments become smaller in accordance with the law of diminishing return. A point will be reached where the increment in gross income is just sufficient to carry the depreciation, maintenance, insurance and ad valorem tax on the increment of investment. This is the point of maximum profit per unit of time. However, it does not correspond to optimum economic design. This is at a lower investment where the increment in gross profit is sufficient to yield also the minimum attractive return on the corresponding increment of investment.

Optimum economic design is properly defined as that which yields the specified minimum attractive return rate on the last increment of investment.

This is contrary to some text book definitions of the optimum as the design which returns the maximum profit; the latter is at fault in that its application calls for investments at return rates below the minimum attractive return, and up to the point at which the return on the last increment is zero.

Preliminary design work is usually based on previous experience and rules of thumb, with attention to only a few details. This procedure is quick and is usually adequate for selecting the general plan of the operation and for deciding whether additional study is justified. However, in preparing the final design of the equipment which is to be installed, detailed studies should be carried out to determine not only that the plant and its components will perform satisfactorily, but also that each item of equipment is designed for its optimum. One day of an engineer's time spent in optimising, in contrast to use of rules-of-thumb, can easily result in annual savings in excess of his salary.

Incremental Profit. For problems involving optimum economic design it is convenient to work with the incremental profit corresponding to a project. Incremental profit is defined as the average annual profit before income tax which equals the incremental present worth. That is,

$$P(1 - \rho_f)(1 - t)F_a = W \qquad (13)$$

The incremental profit of a project may be considered as the profit above that which would be obtained if the capital were invested in marginal projects.

It can be seen from the definition given by Equation 13 that if the design of a project is such that incremental profit is a maximum, the incremental present worth will also be a maximum. This only applies if the tax rate, marginal return rate and periods of construction and operation are constant for the design under study. These conditions usually apply for optimum design studies.

If Equations 4, 8 and 9 are combined with Equation 13 and all elements which do not vary for a particular study are lumped in a constant C, the following equation is obtained:

$$P = C + \frac{R_c}{1 - t} + R_t - E - I_a k_f \qquad (14)$$

$$\text{where } k_f = \frac{k_a + \dfrac{(1+m)^e}{F_a(1-t)} - \dfrac{t\,F_d}{d\,(1-t)F_a} - \dfrac{S_a/I_a}{F_a(1+m)^n}}{(1+m)^e} + 1 - \frac{t}{(1+m)^e} - \frac{(S_a/I_a)(1-t)}{(1+m)^e} \cdot \frac{\rho_f}{F_a(1-t)(1-\rho_f)} \qquad (15)$$

C = sum of all non-variable elements, $/year

The same "fixed charges" rate may be obtained from Equation 10 by taking the derivative of W with respect to I_a.

The fixed charges rate as defined by Equation 15 appears to be rather complicated and its relation to the usual definition is not readily apparent. However, for the case where n is equal to d, the construction period is neglected, and both the salvage value and risk of failure are zero, it reduces to the following:

$$k_f = k_a + \frac{1}{1-t} \cdot \frac{m(1+m)^n}{(1+m)^n - 1} - \frac{t}{n(1-t)} \qquad (16)$$

$$k_f \cong k_a + \frac{1}{n} + \frac{0.63m}{1-t} \qquad (17)$$

The approximate value of k_f for the conditions imposed is simply the sum of capital charges, depreciation based on the period of operation and a charge for the time value of money. The non-conditional definition includes these terms plus others to account for the effects of salvage, risk of complete failure, and period of construction.

Equation 14 is very useful in the optimum economic design of equipment. In the final design of a given study the following procedure may be used:

- Establish alternative process schemes to accomplish the desired objective.
- Consider previous studies, make rough economic

calculations and discuss with others so that the study may be limited to those which appear the more attractive and which can be designed within the time available.

- For each of the alternatives chosen make detailed economic studies to establish the optimum product recovery and optimum operating conditions.
- Choose the design showing the highest incremental profit or incremental present worth.

This complete procedure may be a lengthy and laborious one. However, it is usually justified because the alternative of using engineering rules of thumb often result in substantial losses.

The optimum design, i.e., that corresponding to the proper balance of product recovery and operating costs versus fixed charges, usually involves the choice of a size or dimension of a unit of equipment. Increasing the size of the equipment increases the recovery of products or decreases utilities and other operating costs, and vice versa.

If the incremental profit is a function of only one variable, it is a simple matter to find the proper value of the variable which results in the maximum incremental profit. If the incremental profit is a function of two or more variables, one of two procedures may be followed:

1. Assume reasonable values for all but one of the variables and find its optimum value. Repeat this procedure for each remaining variable using previously calculated optimum values for other variables. Continue this procedure until the desired degree of accuracy is obtained.
2. Write an equation relating the incremental profit to all of the variables. Determine the partial derivatives of this equation with respect to each of the variables. Set the resulting equations equal to zero and solve them simultaneously for the optimum values of the variables.

The optimum design obtained by use of this method differs from most other published methods only in that the fixed charges rate includes all related charges. Most published methods neglect the effect of the marginal return rate.

APPENDIX

Present Worth Factors

Lump sum of one dollar due in c years

$$F_s = \frac{1}{(1+m)^c} \qquad (18)$$

Uniform annual series of one dollar commencing one year hence, and due for n years

$$F_u = \frac{1}{(1+m)} + \frac{1}{(1+m)^2} + \cdots + \frac{1}{(1+m)^n} = \frac{(1+m)^n - 1}{m(1+m)^n} \qquad (19)$$

Geometrically progressing annual series commencing one year hence with an initial payment of one dollar and due for n years

$$F_g = \frac{1}{(1+m)} + \frac{(1+g)}{(1+m)^2} + \frac{(1+g)^2}{(1+m)^3} + \cdots + \frac{(1+g)^{n-1}}{(1+m)^n} = \frac{1 - \left(\frac{1+g}{1+m}\right)^n}{m-g} \qquad (20)$$

Uniform series of one dollar commencing r years hence and recurring every rth year for n minus r years

$$F_r = \frac{1}{(1+m)^r} + \frac{1}{(1+m)^{2r}} + \cdots + \frac{1}{(1+m)^{n-r}} = \left(\frac{(1+m)^n - 1}{m(1+m)^n}\right)\left(\frac{m(1+m)^r}{(1+m)^r - 1}\right) - 1 \qquad (21)$$

Uniformly progressing annual series commencing one year hence, with an initial payment of one dollar and due for n years.

$$F_u = \frac{1}{1+m} + \frac{2}{(1+m)^2} + \cdots + \frac{n}{(1+m)^n} = \frac{1+m}{m}\,\frac{(1+m)^n - 1}{m(1+m)^n} - \frac{n}{m(1+m)^n} \qquad (22)$$

Any of these present worth factors may be converted to a base with the first payment commencing an additional c years hence by multiplying by $1/(1+m)^c$.

ACKNOWLEDGMENT

The constructive comments and suggestions by L. R. Steffens are gratefully acknowledged.

NOTATION

A = incremental present worth of a service, dollars
C = summation of all non-variable costs, $/year
c = construction period or time capital is committed prior to operation, years
d = number of years used for depreciation purposes
E = operating expenses
$F_d = [(1+m)^d - 1]/(m)\ (1+m)^d$
t = income tax rate, fraction/year
$F_u = [(1+m)^n - 1]/(m)\ (1+m)^n$
g = increase in a sum due (Eqn 18), fraction/year
i = average return on investment by Equation 11
I_a = investment in tangible assets, dollars
I_c = investment in intangible assets, dollars
I_t = total investment in facilities, dollars
I_r = investment of a recurring nature, dollars
I_w = investment in working capital, dollars
k_a = capital charge rate on tangible assets, fraction/year
k_f = fixed charges rate, fraction/year
k_r = capital charge rate on recurring investments, fraction/year
k_w = capital charge rate on working capital, fraction/year
m = minimum attractive return rate, fraction/year
n = number of years of anticipated operation or remaining years of operation
R = revenue from sale of products and services after deducting sales and severence taxes, $/year
r = years of useful life of recurring type assets
S_o = salvage value on start-up or immediately, dollars
S_n = salvage value after end of operation, dollars
s = a sum due, dollars
W = incremental present worth, probability of failure and success considered, dollars
W_f = incremental present worth if a failure, dollars
W_s = incremental present worth if a success, dollars
ρ_f = probability of failure, fraction

Subscripts

1, 2 = 1st, 2nd . . . year
e = tax exempt
f = as a failure
n = nth year or to designate present worth factor
s = as a success
t = taxable

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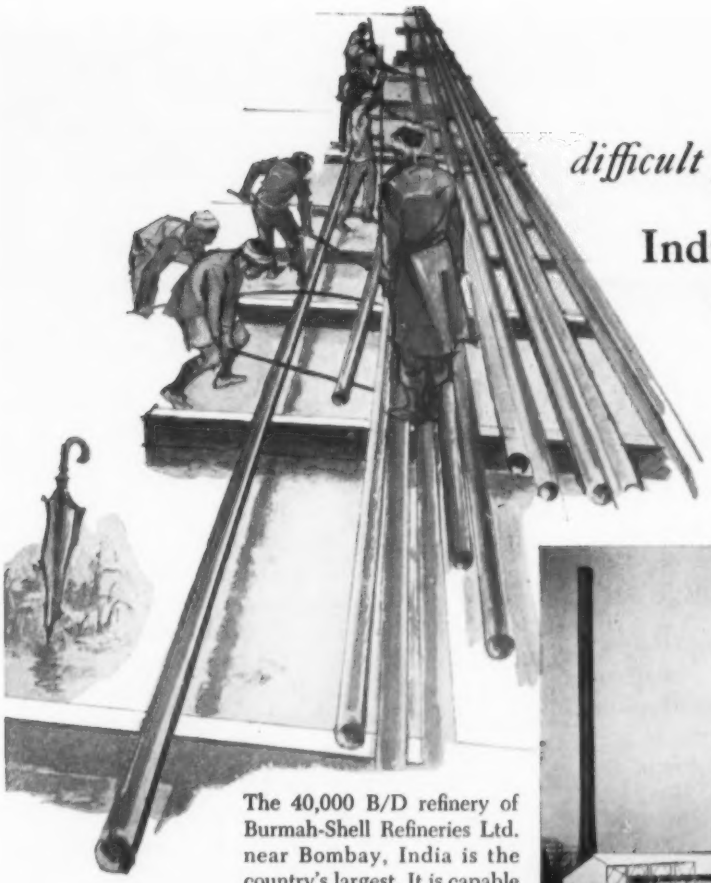
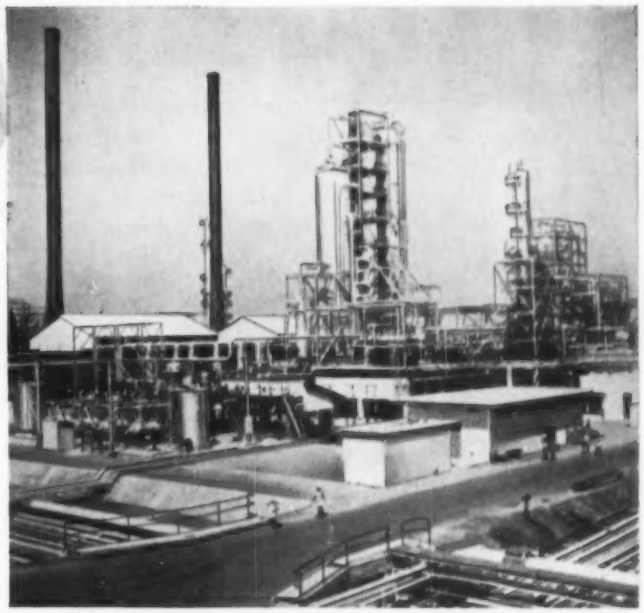


difficult physical conditions, but...

India's largest refinery was completed a year ahead of schedule



The 40,000 B/D refinery of Burmah-Shell Refineries Ltd. near Bombay, India is the country's largest. It is capable of supplying an estimated half of India's current requirements for finished petroleum. Although built in the face of difficult physical conditions, close cooperation with the owner in planning and engineering, and exceptional coordination of construction allowed Lummus to finish almost a year ahead of the original schedule.

A smoothly running refinery now, consisting primarily of crude distillation, fluid catalytic cracking, gas recovery, treating and blending units, offsite facilities and utilities, at the start it was only 450 acres of incredibly difficult terrain, without roads, railway or harbor.

Battling two of Bombay's worst monsoons, Lummus employed as many as 14,000 Indians at peak periods. Terrain was filled and drained. Roads, rail lines, harbor facilities, and the complete refinery were constructed. The job was kept moving *ahead* of the timetable – and finished 21 months from the start of construction.

A project of this magnitude requires a worldwide organization of experienced engineers and construction men able to cope with any problem. Lummus is such an organization and can design and build your next plant whatever the size, type or location.

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A What?

Do you ever need a Bodemmonster-Trekker? If you do and find that one is not available from your local supply house, try making your own. Details for making one of this handy devices in your own plant shop will be found in "How to Do It." **Keep Going to Page 214.**

On Stream

In Turkey, the refinery at Batman has been completed after nearly three years of construction and is now processing about 7000 barrels a day. An interesting point about this refinery is that it has been operating at near capacity since the distillation unit was completed almost a year ago. For a description of the plant, the needs peculiar to its market and the characteristics of the crude it was built to refine, see "Who's Building." **Keep Going to Page 223.**

Plans for '59

The Fifth World Petroleum Congress will be held in New York in 1959. Some of the details of that meeting already are available—as for example, the name of the man appointed to serve as its secretary general. For this and other important details of the first congress to be held in the U. S. since the organization was formed in 1900, see "What's Happening in Industry." **Keep Going to Page 276.**

Among Men

Who is moving ahead in the industry? Well, C. Calvin Naylor is taking over as manager of Sun Oil Company's Marcus Hook refinery; A. E. New, who was with Carbide and Carbon Chemicals Company at Texas City, has been picked to direct the Technical department of Escambia Bay Chemical Corporation; and Philip A. Kahle, Jr., has been made general manager of refining for Frontier Refining Company. These are only a few of the people receiving new assignments in the refining-natural gasoline-petrochemical industry. For the names of others, see "What's Happening Among Men in the Industry."

Keep Going to Page 284

Advanced Account

The use of chemicals in petroleum refining is the subject of one of the books reviewed this month. Written by two authorities whose contributions have appeared frequently in Petroleum Refiner, this book is described by the reviewer as "an advanced account" of various refining problems. **Keep Going to Page 253.**

On One Pot

One of the items taken up this month in "What's New in Equipment" is a dual-operator sandblast machine, equipped to permit two sandblasters to blast from one pot. For more information on this, or any of the more than 30 other pieces of new equipment covered in this department, use the "Readers' Service Card" inside the back cover.

Keep Going to Page 304.

With 10 years on corrosive waste gases this Crane Valve is still maintenance-free

THE CASE HISTORY—For over 10 years, a large integrated refinery has handled corrosive waste gases on its refinery flare line with this 10-inch No. 47X Crane cast steel 150-pound valve. Used as the main gate valve, it is operated about once a month.

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Actually, Crane case histories like this are quite common in oil refineries. You'll find Crane valves on practically every type service with similar performance records.

From the outside, Crane valves may look like many other makes, but inside, it's a different story. Here you'll find the famed Crane quality in design and construction—in the precision fit and superior alloys that assure maintenance-saving, trouble-free operation.

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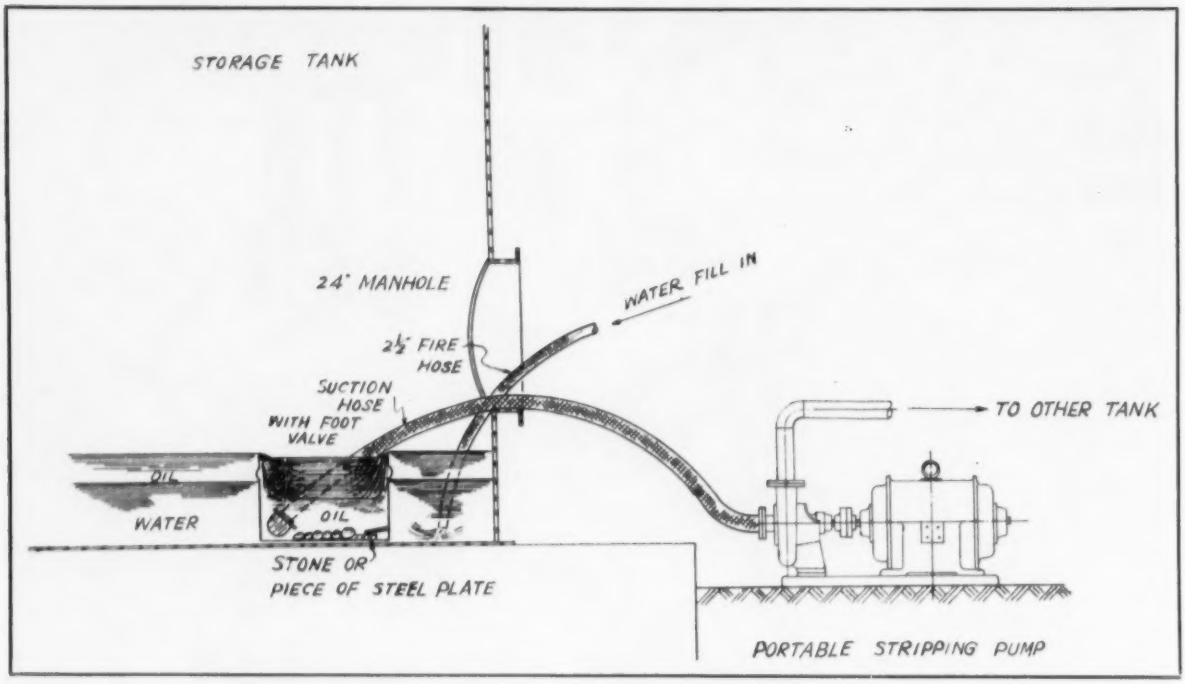

Remove Stock Without Scraping Bottom

益廣思集

An Old Chinese Proverb . . .

. . . "A collection of thoughts is always beneficial."

Because it is a collection of thoughts —from all over the world—How To Do It is one of Petroleum Refiner's most popular features.

Apparently the ingenuity expressed by contributors to this column is contagious. This month we are featuring four ideas submitted by readers from China, Egypt and Holland.

We know there are hundreds of ideas submitted every month by refinery people through their company suggestion plans. If you'll take the time (and it doesn't take much time) to jot these down in a notebook—then tear out the page and send it to us with a sketch or snapshot—we'll be glad to pay from $10 to $20 for each one accepted. Do it now!

There are times when it is not necessary to scrape the tank bottom for a change of service but when it is desirable to remove as much of the previous stock as possible. Here is a method which has saved many man-hours in stripping out those last few inches of "old" product. This is what you do:

- Lower the tank level below the manhole.
- Open the manhole and place a cut-down 55 gallon drum on the tank bottom. This drum should be weighed down with pieces of concrete or steel plate.
- Locate a suitable pump outside the tank beside the manhole.
- Now place the suction hose equipped with a foot valve inside the drum.
- Use a fire hose to add water into

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1. A CAP
2. A DISC
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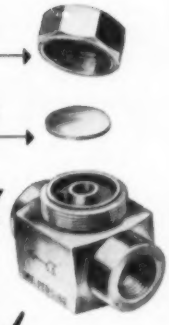

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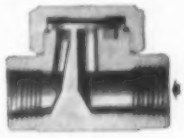

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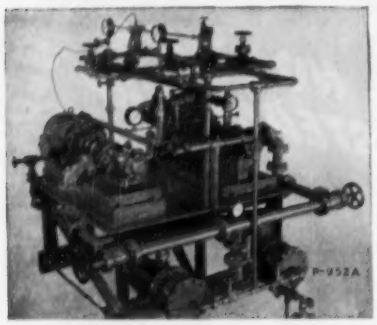

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How to Do It . . .

the tank through the manhole.

By controlling the water feed rate, oil is floated into the sump drum at just about the same speed as it is pumped out. Usually only a very thin layer of oil is left on the tank bottom when the job is finished.

Another advantage of this method is that the stripped oil is usually much cleaner than with other methods and can be reused.

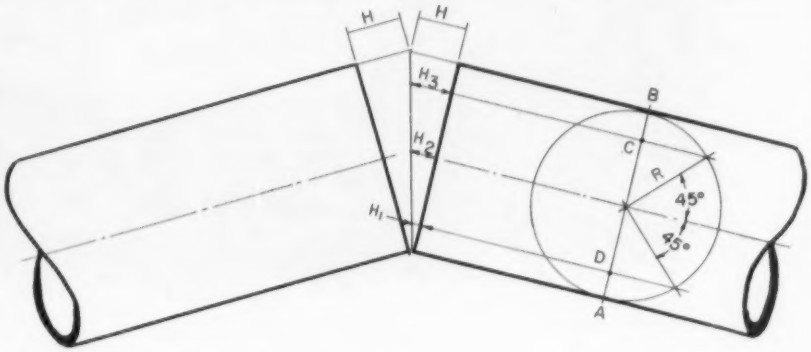
This idea was submitted by:
Yang Tzen-yung
Maintenance Division
Kaohsiung Refinery
Chinese Petroleum Corporation
Kaohsiung, Taiwan

Change Drainage Valves Without Losing Stock

Here's another novel idea submitted by Mr. Yang:

You can replace damaged tank inlet or drainage valves without first emptying the tank if you follow this simple procedure:

1. Using a fire hose, add water to the tank until the product is floated to a level about one foot higher than the position of the damaged valve.
2. Remove the damaged valve and quickly clean the tank flange.
3. Immediately install the spare valve which is in the opened



Simple Pipe Template Cuts Fabrication Costs

Field fabrication of piping frequently requires that two intersecting pipes be joined or a single pipe be angled to some new direction. The odd-angled joint can be assembled much quicker if a template is available to cut the approximate curvature on the pipe.

Here is an easy way to make a template with no special tools or measuring devices. A ruler or tape, triangle, and paper and pencil are all you need to make a template for any angle pipe joint.

First, cut the paper to the exact length needed to go around the pipe. Then fold the paper three times. This will divide it into eight equal parts (try it). Now measure the distance *H* by extending a stick along the top surface of each pipe. Lay off the template curve with the dimensions shown in the lower sketch of the drawing above. The rest of the drawing is a proof of the dimensions.

Submitted by Mr Yousef Ilyahim Mah.
c/o Mobil Oil Egypt, Inc.
Sh. El. Gomhoria
Cairo, Egypt

$$\overline{OC} = \frac{R}{\sqrt{2}} = .707R$$

$$\overline{AC} = R + .707R = 1.707R$$

$$\overline{AD} = R - .707R = .293R$$

By Proportion:

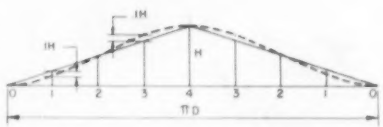
$$\frac{H_2}{H} = \frac{\overline{AC}}{2R} = \frac{1.707R}{2R} = .8525$$

$$H_2 = .8535H = \text{approx. } .85H$$

Also

$$\frac{H_1}{H} = \frac{\overline{AD}}{2R} = \frac{.293R}{2R} = .1465$$

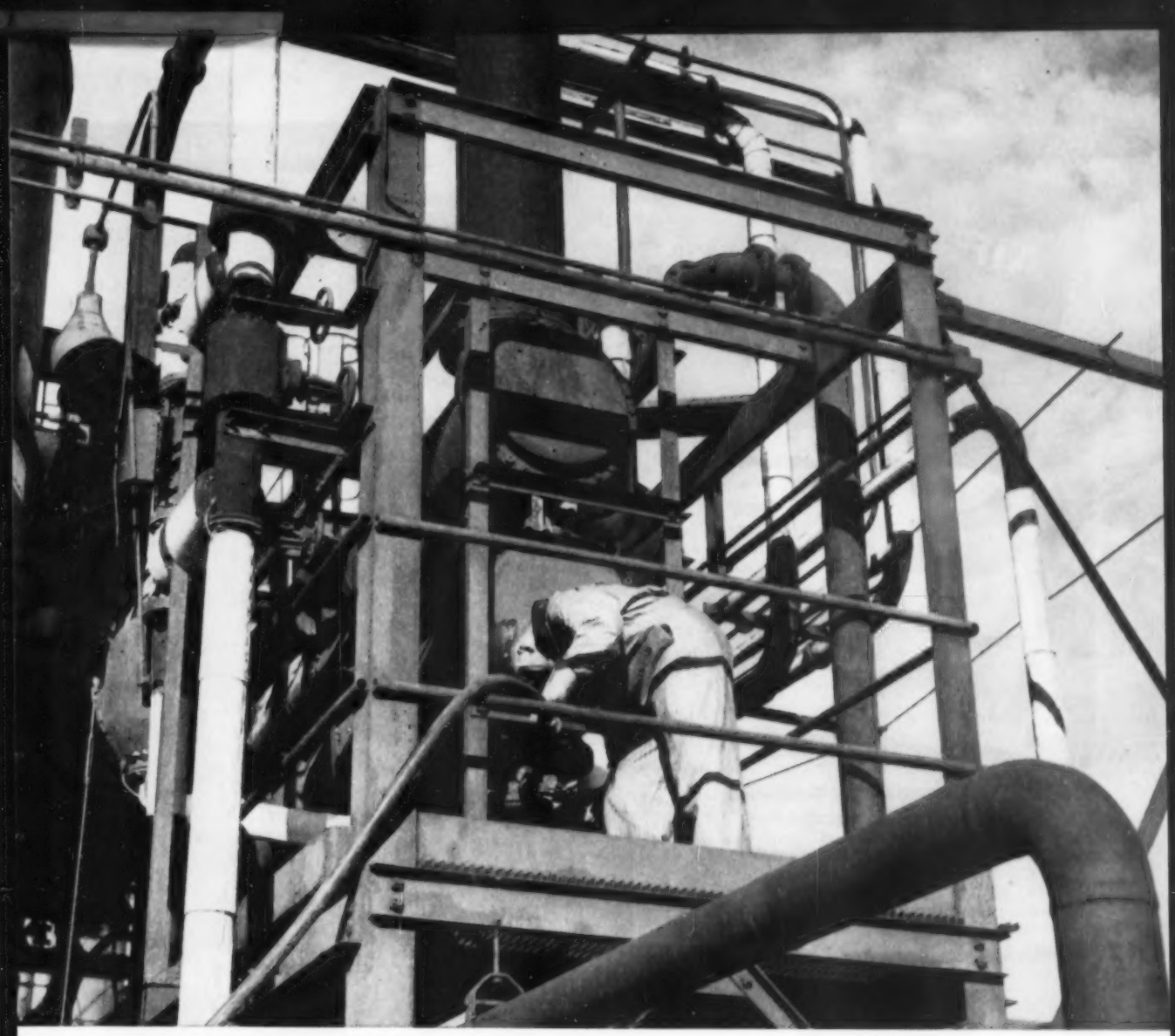
$$H_1 = .1465H = \text{approx. } .15H$$



At Point 1, the height of the triangle = .25H
the height of the curve = .15H
difference = .1H

At Point 2, the height of the triangle =
the height of the curve = .5H

At Point 3, the height of the triangle = .75H
the height of the curve = .85H
difference = .1H



There's too much at stake —clean it right

Chemical cleaning involves costly equipment and often work stoppages. It's a job for experts. Let Dowell protect that equipment and keep production losses to a minimum when you have scale or sludge problems.

In over 15 years our trained engineers have serviced virtually every kind of equipment in plants, mills and refineries throughout industry. In fact, Dowell has cleaned over 10,000 boilers alone!

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Furthermore, Dowell engineers know you value the safety of your men and equipment. Dowell uses only the latest safety equipment and techniques to eliminate hazards and accidents. Our engineers work closely with your safety personnel to establish the safest possible working procedures.

Call the nearest of more than 165 Dowell offices. An experienced engineer will be glad to talk over and help you with your cleaning problems any time — at no obligation. Or write Dowell Incorporated, Tulsa 1, Oklahoma, Dept. G-31.

chemical cleaning service for industry

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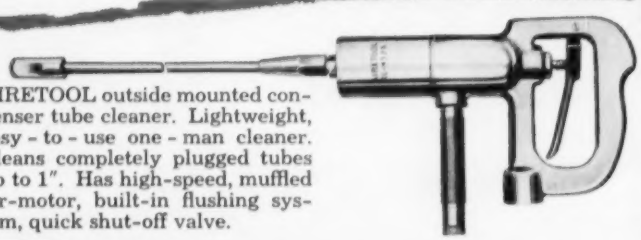
Look no further than AIRETOOL for dependable, cost-saving tube maintenance equipment. Precision made Airetool tube cutters, cleaners, expanders, accessory and specialty tools meet **every** tube maintenance need. Save time and money on **every** job.

NEW . . . AIRETOOL Internal Tube Cutter. New single-stage, air-driven motor is designed and built by AIRETOOL. Quickly, inexpensively removes damaged or leaky condenser tubes. Optional electric motor for use where air supply is not available.



AIRETOOL outside mounted condenser tube cleaner. Lightweight, easy-to-use one-man cleaner. Cleans completely plugged tubes up to 1". Has high-speed, muffled air-motor, built-in flushing system, quick shut-off valve.

AIRETOOL Automatic Tube Expansion Control . . . automatically, accurately rolls tube joints to proper tightness. Portable unit goes right to job site.

AIRETOOL Tube Removal Tools are great for retubing a bundle. Quickly and efficiently remove tubes and tube stubs from condenser tube sheets.

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Write for illustrated literature on condenser tube maintenance tools.
Ask for Bulletin #59.

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EUROPEAN PLANT: Vlaardingen, The Netherlands.

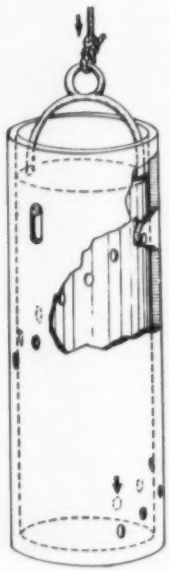
How to Do It . . .

position.

4. Insert a new gasket and tighten some of the bolts.
5. Close the valve and tighten the rest of the bolts.

Be sure the spare valve has been opened before installing it; otherwise the force of the water splashing out between the flange faces will prevent inserting the gasket.

The three-inch tank drainage valve shown here was changed in only seven minutes using this method.



Do It Yourself Bodemmonster-Trekker

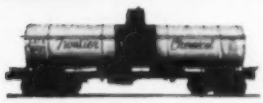
You can make this handy bodemmonster-trekker in your own plant shop. It's a device for obtaining bottom samples in oil storage tanks to determine how much water, sludge, emulsion and clean oil is present at the tank bottom.

The sampler can be made of bronze. Just make sure the cylinder walls are very smooth and with only enough clearance to slide freely when a film of oil is between the cylinders.

All ports open simultaneously when the outer cylinder touches the tank bottom; all ports close when the sampler is pulled up.

Submitted by P. de Vos
Butaanweg 19 A Rotterdam-Pernis
(Nederlandsche Opslag My.)

the fleet grows!



We have just added 55 new tank cars to the Frontier Chemical fleet. Our total of cars at your service now ranges respectably into the hundreds. Not the largest fleet on the rails, of course. But – backed by close followup of each car, and prompt shipment over uncongested routes from our strategic plant locations – it spells faster deliveries to you . . . and cost-cutting reductions in your chemical stockpiles. Here's a typical aspect of service in the Frontier spirit – friendly, helpful, and backed by all the resources necessary to meet your needs. For off-rail locations, Frontier's truck fleet is always at your call. We shall welcome an opportunity to serve you.

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producers of caustic soda (liquid, flake, solid) • muriatic acid • chlorine • 99% pure salt (fine grain or briquette)

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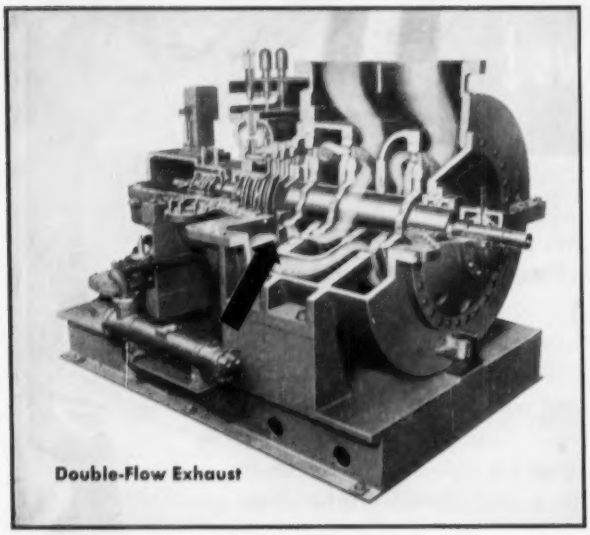
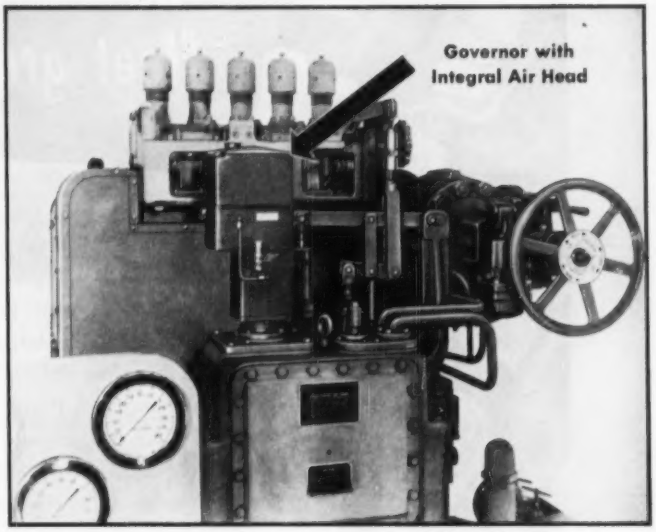
In high-speed turbines . . . why does in total horsepower and



GREATER RELIABILITY. Worthington's rugged construction pays off in extra reliability. Solid rotor for modern high speeds, double-flow exhaust where large volumes of steam are used in condensing operation, and Kingsbury type thrust bearings are just a few of the features that assure safety and dependable service on your vital compressor and blower drives.



ACCURATE SPEED REGULATION. Exclusive Worthington governing system using governor with integral air motor gives you speed control response to .04 psi change in control pressure. And it provides for remote automatic operation if you need it. The oil relay type governor so equipped instantaneously controls pressure or volume delivered by the compressor regardless of steam variations.

Where turbine-driven compressors and blowers are used, down-time is usually mighty expensive. Particularly so if failure can bring a continuous process to a standstill. In the case of high-speed/high-horsepower compressor-drive turbines, your surest way to design reliability into your plant is to specify the turbine line with best *proven* performance.

Compressor-drive turbine installations up to 12,000 rpm, and 24,000 hp, show Worthington leads in application engineering, design, reliability.

Worthington compressor-drive turbines are conservatively built with all stresses carefully calculated and kept well within established safety margins. Also, measured load tests are performed on every unit at the factory with modern facilities, under the watchful eyes of highly trained personnel.

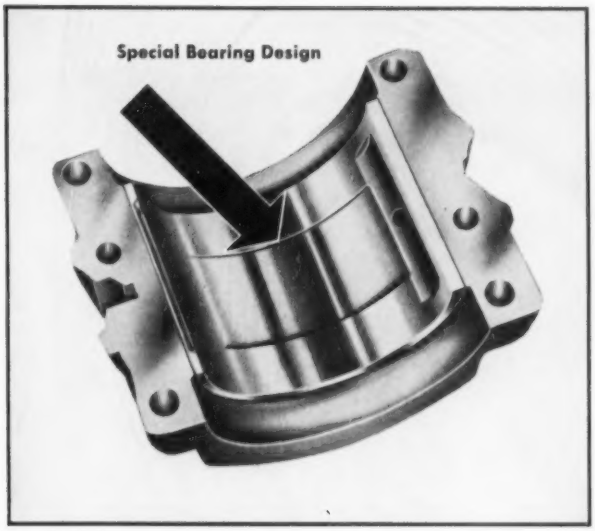
One feature seldom claimed is that of lowest price. That is inconsistent with quality, and quality is something Worthington engineers will not compromise. For critical operations, buying the best is lowest cost insurance against process equipment failure.

Get the complete story of high-speed/high-horsepower compressor-drive turbines by writing Worthington Corporation, A&SP-Turbines, Harrison, New Jersey. Ask for your personal copy of Bulletin 1966.

On Vital Compressor and Blower-Drive Applications . . . It Costs Less to Invest in the Best!

WORTHINGTON

WORTHINGTON lead all others number of installations?

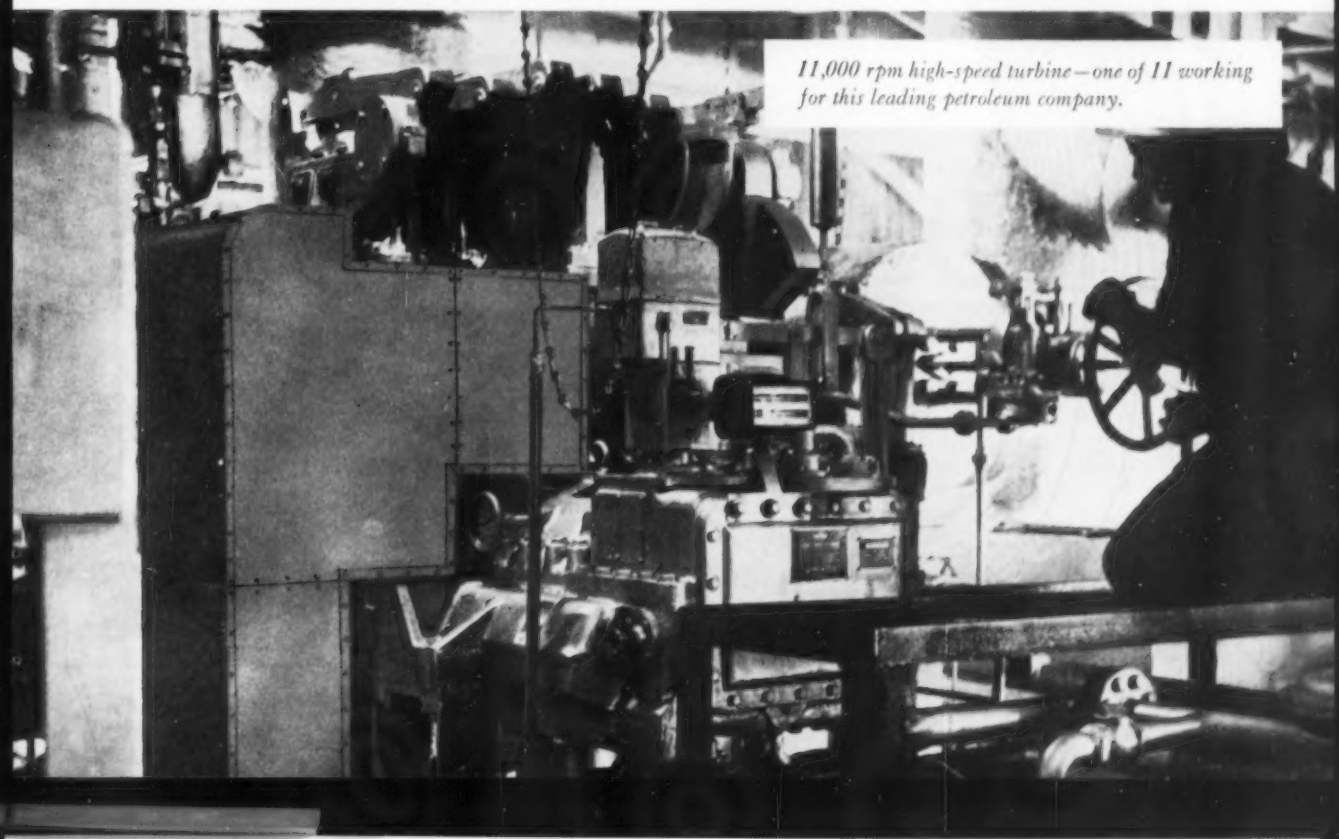


To meet turbine spec's. 4000 Hp- 7250 RPM -Steam 210 #-550°-26½"
WORTHINGTON GIVES YOU ALL THIS—CHECK AND COMPARE:

	Feature	WORTHINGTON	Company A	Company B	Company C
Roter	Solid—to withstand extreme stresses.	✓			
Main Bearings	Anti oil-whip—for longer turbine life.	✓			
Thrust Bearing	Kingsbury type—for proven reliability.	✓			
Automatic Nozzle Control	Cam operated—for economy and better control.	✓			
Governor	Has integral air motor—for more accurate control.	✓			
Type Construction	Double flow exhaust for economy and long life.	✓			
Packing	Labyrinth—for most effective seal at high speed.	✓			
Test	Load test—to be sure you get what you ordered.	✓			

LOWER MAINTENANCE COST. One important example of construction used to help eliminate non-scheduled maintenance is Worthington's anti oil-whip bearing. During operation a pocket (arrow) in the upper half of the bearing builds up a pressure pad of oil. High pressure here creates a downward force on the journal, holding it in place in the bearing, preventing destructive vibration.

LONGER LIFE. A long, trouble-free life can be attributed to no *one* turbine feature, but rather a combination of many engineering advances. Compare design features yourself, one by one. Far ahead of any other manufacturer in the compressor-drive field, Worthington's first compressor-drive turbine built in 1927 is still working around the clock, in a large Eastern gas plant.



11,000 rpm high-speed turbine—one of 11 working for this leading petroleum company.

FLEXITALLIC IS A WAY OF THINKING

Consider the job that a FLEXITALLIC Spiral-Wound Gasket must do in high pressure process piping, in boiler and other pressure vessel "windows", in containing corrosive chemicals, and in steam lines of ships at sea.

In these and similar applications, where engineers are seriously concerned with confining fluids safely, notice the blueprints. See how often they call for Flexitallic Spiral-Wound Gaskets. It's "engineering's" way of thinking — safely.

More than 40 years ago, Flexitallic ushered in a new era of high-temperature, high-pressure sealing. Today, with flange standards of 2500 lbs. and 1050°F., Flexitallic Gaskets assure the safety of operating personnel, while protecting property valued in the billions of dollars.

Each Flexitallic Gasket is designed and engineered to meet specific conditions of thermal and physical shock, corrosion, vibration, weaving and unpredictable joint stresses. Spirally-wound V-crimped plies of required metal with alternating plies of proper filler result in a resilient gasket having controlled compression characteristics like those of a precalibrated spring.

Flexitallic Gaskets are at highest efficiency when bolted up cold at a predetermined load. For all pressure/temperature ranges from vacuum to 10,000 lbs., from extreme subzero to 2000°F. For all standard joint assemblies. In four thicknesses for special requirements: .125", .175", .250", .285".

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TEFLON FOR PROCESS APPLICATIONS

The ideal seal for many process applications is a Flexitallic Gasket with Teflon trapped between edges of stainless steel. Ask for folder, "Teflon in Flexitallic Gaskets."

*Flexitallic is a registered trade name. No one else can make a Flexitallic Gasket. Look for *Flexitallic Blue*—it's our exclusive blue-dyed Canadian asbestos filler.

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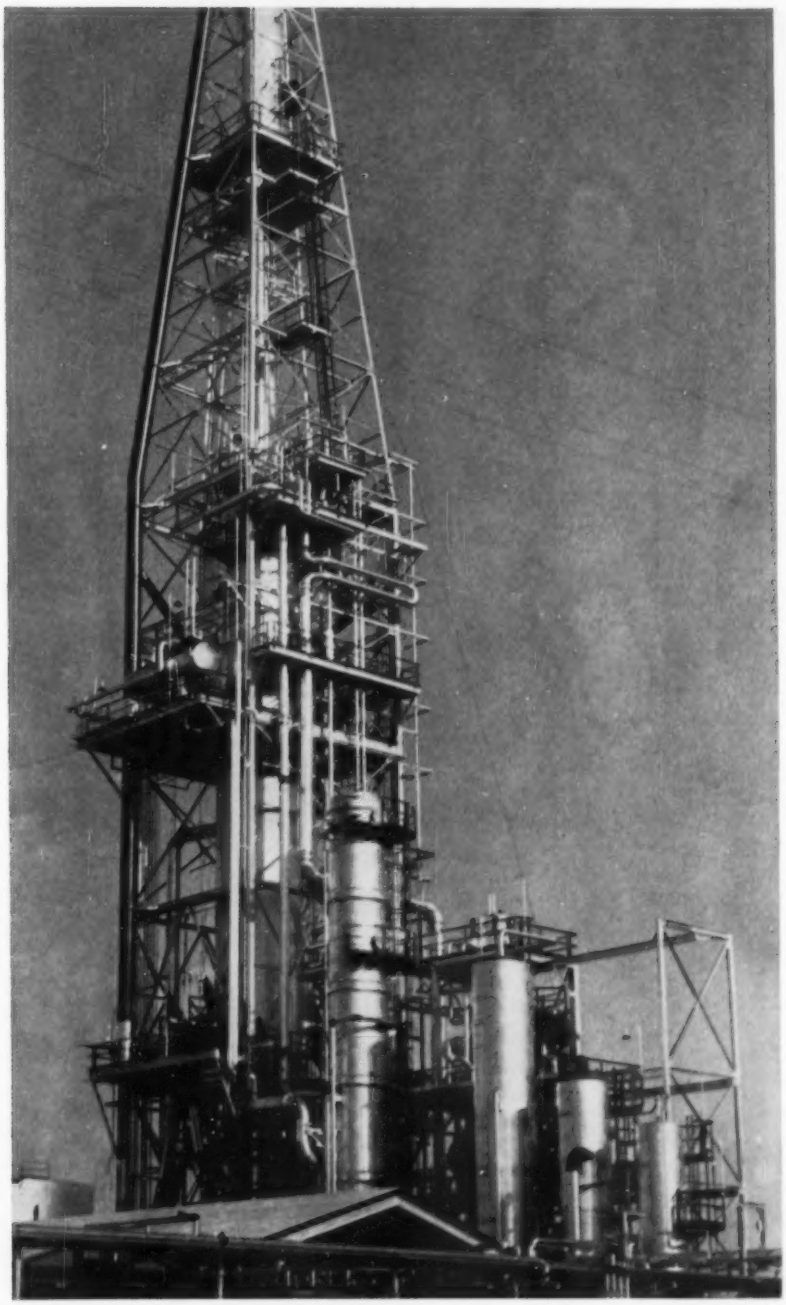
Who's Building . . .

Construction Boxscore begins on page 232.

New Turkish Refinery Complete



Batman Refinery Now Operating At 7000 BPD

NEAR-CAPACITY operation has been maintained at the new Turkish refinery near Batman since the crude-distillation unit went on stream in August 1955 and the thermal catalytic cracker was completed in December.

Now finished, the $14-million refinery is receiving 7000 barrels of crude oil a day for processing into 1430 barrels of high-octane gasoline, 3120 barrels of railroad fuel oil, 500 barrels of jet fuel and 1420 barrels of asphalt.

The refinery is owned and operated by Turkiye Petrolleri, A. O., an organization with controlling interest held by the government of Turkey, and 49 percent of the ownership available for private investment.

Construction and design of the refinery, as well as procurement of materials, training of personnel and initial operation of the refinery, was performed by The Ralph M. Parsons Company.

The first part of the project completed was the pipe line from Ramandag to Batman. The first crude oil flowed to the refinery site in late 1953.

This oil was burned by the railroad locomotives, releasing coal for other uses. The railroad built up its consumption to about 2,500 barrels a day, assuring an outlet for production of the refinery when it was completed.

Meanwhile, the refinery construction continued. The crude unit and asphalt still went on stream in mid-1955 and have been running at capacity ever since. The central power plant and catalytic cracking unit be-

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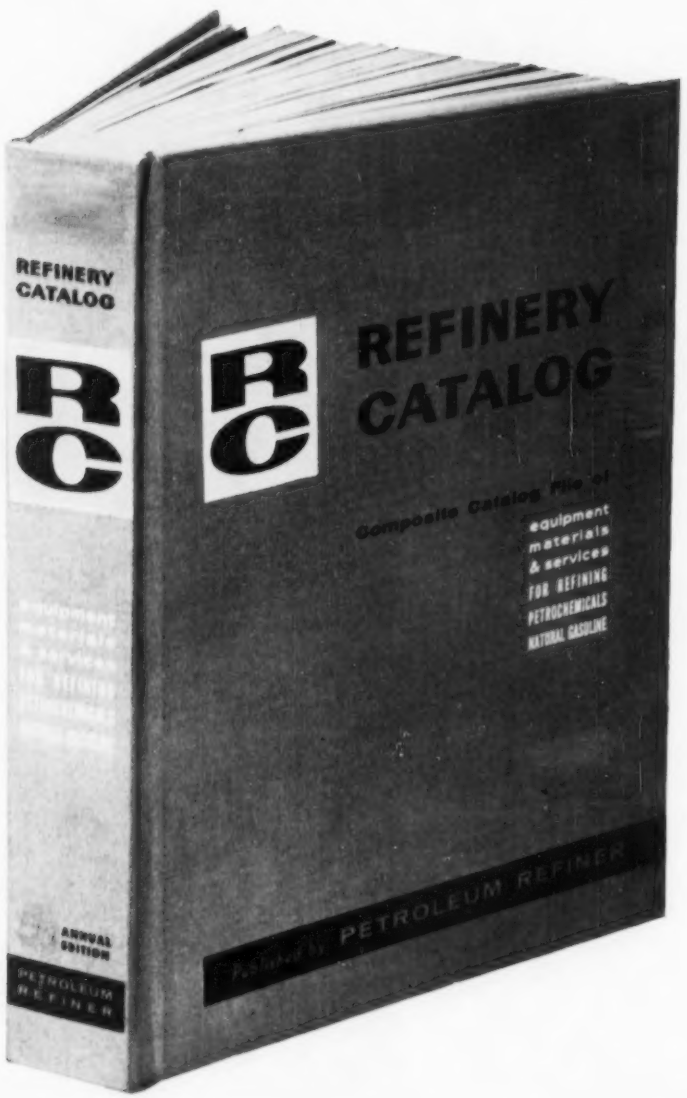

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gan operation a few months later.

Ramandag crude has an asphalt base and is noteworthy for the high sulfur content, the small quantity and low octane number of the gasoline, and the high viscosity of the residue. These are characteristics of the crude:

RAMANDAG CRUDE

Gravity—°API @ 60 F.	20.5
Sulfur—Wt. %	3.5
Viscosity—SSU @ 100 F.	480
Salt Content—Grams/bbl.	55.8
BS&W—Vol. %	0.1
Pour Point—F.	5

Preliminary studies and the operation of an old shell still refinery at Batman showed that acceptable products could be made by relatively-simple processing.

Studies indicated the most suitable processing arrangement would comprise atmospheric distillation, vacuum distillation for asphalt, viscosity breaking, and catalytic cracking. But pilot-plant experiments disclosed an anomaly in that the Ramandag residue was not amenable to viscosity breaking at any practical combination of temperature and pressure. The viscosity-broken residue was more viscous than the charge stock when stabilized to meet flash and fire point specifications.

The most practical way to meet railroad fuel oil viscosity specifications was found by blending heavy virgin residuum with cracked gas oil and heavy naphtha from the catalytic cracking unit. As a result, the design was changed to eliminate the viscosity breaker and a vacuum still was added to prepare the maximum quantity of feedstock for the catalytic cracker.

Turkish American Oil Company, a new concern being organized to operate a refinery in Turkey, has received a government permit to build a 15,000-barrel-a-day refinery at Istanbul.

Facilities for the new plant will include crude and vacuum distillation, catalytic cracking, vapor recovery, catalytic polymerization, treating units and auxiliary equipment. The refinery is scheduled for completion in August 1958.

This will be Turkey's second new refinery. Turkiye Petrolleri, A. O., recently completed a 6950-barrel-a-day refinery at Batman.

The Standard Oil Company (Ohio) will build a new integrated refining facility at Toledo, Ohio, where it already is operating a 23,000-barrel-a-day refinery. The new plant, expected to cost about $35 million, will have a daily capacity of 60,000 barrels and will be designed to handle either sour or sweet crudes. Construction will be started in 1957, with the plant scheduled for completion in the first part of 1959.

Foster Grant Company, Inc., has completed a $1,665,000 expansion, doubling capacity of its styrene-monomer plant at Baton Rouge, increasing capacity of its polystyrene plant at Leominster, Mass., by 50 percent, and tripling the size of its research laboratory.

The B. F. Goodrich Chemical Company has started construction of a $5-million project to provide additional polyvinyl-resins and plastic-compound facilities for its plant at Avon Lake, Ohio.

The contract is held by The Girdler Company, which built the original Goodrich plant at Avon Lake in 1950. Construction is expected to be completed in March 1957.

Eastman Kodak Company has been licensed to use the rigid polyethylene process developed by Standard Oil Company (Indiana). The company was licensed for commercial production of high-density polyethylene and polypropylene plastics under more than 20 patents issued to Standard Oil research scientists since 1951. Other patents are pending.

The British Petroleum Company, Ltd., has started construction on a major expansion of its 90,000-barrel-a-day Kent refinery, near London. The project, expected to cost some $73 million, will increase the refinery's daily crude capacity to 140,000 barrels. These are the major processes to be added:

- Distillation—90,000 barrels a day.
- Catalytic reforming—10,000 barrels a day.
- Thermal reforming—10,000 barrels a day.
- Hydrofining—two units, each for 10,000 barrels a day.
- Crude stabilization—12,000 barrels a day.
- Alkylation—2600 barrels a day.

Construction is due to be completed late in 1957.

Esso Petroleum Company, Ltd., has completed a new 15,000-barrel-a-day catalytic-reforming unit at its Fawley refinery in Great Britain. The unit is a Hydroformer licensed by the affiliated Esso Research and Engineering Company. Foster Wheeler Corporation was in charge of the $11,200,000 project.

Who's Building . . .

Chinese Petroleum Corporation has completed the second of two new refining units on Formosa. At Kaohsiung, the unit is a 10,000-barrel-a-day Thermofor catalytic cracker, licensed by Socony Mobil Oil Company. Engineering and construction was handled by The Fluor Corporation, Ltd.

The refinery's first major new unit was a 3100-barrel-a-day catalytic reformer, completed in 1955. The Atlantic Refining Company licensed the unit, and it was engineered and constructed by Blaw-Knox Company.

Continental Oil Company has gone on stream with a new 1500-barrel-a-day catalytic-reforming unit at its refinery at Artesia, N. M. The unit, a Houdriformer built at a cost of $500,000, will process straight-run naphthas to produce high-octane gasoline-blending stock. The Refinery Engineering Company designed and built the unit.

Union Carbide & Carbon Corporation will put up two new plants to produce low-pressure polyethylene. The units, to be at Institute, W. Va., and Seadrift, Texas, will have a combined capacity of 55 million pounds. They are slated for completion in 1957.

The new facilities will use a number of new techniques—the Ziegler and Phillips

To Exceed 100 Octane

Socony Mobil Oil Company's newest catalytic reformer, the largest of its kind in the world, has gone on stream at the company's Paulsboro, N. J., refinery.

The new unit has a throughput capacity of 20,000 barrels a day. It will be used to convert heavy naphthas into gasoline with antiknock qualities exceeding 100 octane.

The plant, designed by Socony Mobil engineers, employs a special-type alumina catalyst valued at more than $1 million. The unit includes feed-preparation equipment for pre-treating charge stocks with hydrogen to reduce sulfur and remove moisture.

A similar unit, with a capacity of 9000 barrels a day, has gone on stream at Socony Mobil's East Chicago refinery. Additional units are nearing completion at company refineries at Trenton, Mich., and Buffalo, N. Y.

Who's Building . . .

low-pressure processes, under which Carbide is licensed, and several new methods developed in Carbide's own laboratories.

Societe Francaise des Petroles BP, French affiliate of The British Petroleum Company, Ltd., will build a new distillation unit to replace some of the plant at its 44,000-barrel-a-day Lavera refinery, near Marseilles.

The new unit will be designed to increase thruput to 60,000 barrels a day. Since World War II, capacity at Lavera has been increased from 10,000 barrels a day to its present thruput by converting and modifying old distillation equipment.

Clark Oil & Refining Corporation is planning a $5-million program to increase capacity of its Chicago refinery from about 20,000 barrels a day to 30,000. The project, to take about two years, will add a second catalytic cracking unit with a daily capacity of 15,000 barrels, gas-recovery facilities, a vacuum unit, an alkylation unit and a crude heater.

Regent Oil Company, Ltd., is planning to build a refinery with an initial charge capacity of 10,000 barrels a day, probably in southern England. Work is expected to be started by late 1956, with the refinery scheduled to go on stream some time in 1958. Regent Oil is a British marketing concern owned by The California Texas Oil Company, Ltd., and Trinidad Leaseholds, Ltd.

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Standard-Vacuum Refining Company (Australia), Pty., Ltd., has brought on stream Australia's first unit for the manufacture of aviation gasoline. The alkylation unit, at Stanvac's Alton refinery, was built to produce 1600 barrels of avgas a day. This is about half the country's requirements for non-military aviation. Designed by The M. W. Kellogg Company, the new unit was installed at a cost of $4 million.

Republic of Panama has signed contracts with two companies to build and operate refineries in Colon.

Refineria Panama, S. A., will build a refinery with a charge capacity in excess of 50,000 barrels a day. The company is a new affiliate of New York's National Bulk Carriers.

And Refineria Petroquimica de Panama, S. A., will build a 55,000-barrel-a-day refinery and an $11-million anhydrous-ammonia plant. This company is headed by John M. Shaheen of New York.

It was believed that each of the refineries would cost about $30 million to build. Construction is expected to start early in 1957.

Imperial Oil, Ltd., has a $2-million improvement program planned for its Montreal refinery. The work will bring the company's spending on enlarging and improving to the refinery to more than $40 million since World War II.

About half the program will be to improve maintenance facilities. A central maintenance building will be erected and modern equipment installed. The balance of the program will provide improved shipping facilities and a new cooling tower.

The refinery is Canada's second largest, exceeded only by Imperial's refinery at Sarnia, Ont. Its capacity was increased 25 percent in 1955 upon completion of a $10 million construction program. A catalytic reforming unit is now being built as the main item in a $5-million program of improvements.

Sun Oil Company has broken ground for a new laboratory building at its Toledo refinery. The laboratory will be the predominate building in a group of three structures which include a medical dispensary and a gatehouse. Completion is scheduled for November 1956, with the cost of the project expected to run $600,000.

Wilshire Oil Company, planning ultimately to double the capacity of its 25,000-barrel-a-day refinery at Norwalk, Calif., has taken the initial step in its program by awarding the contract for engineering and construction of a 10,000-barrel-a-day Unifining-Platforming unit.

The contract, for $2,750,000, went to Southwestern Engineering Company. The new unit, licensed by Universal Oil Products Company, is due to go on stream early in 1957.

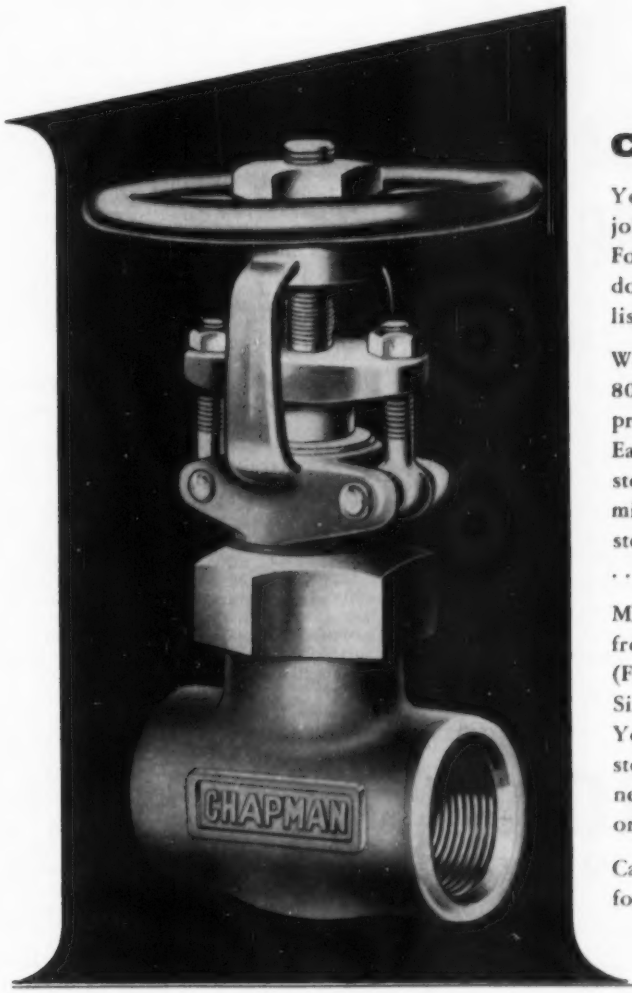
American Cyanamid Company is planning large-scale commercial production of a new acrylic textile fiber. Construction of a plant, probably in northern Florida, will start in December 1956, with plans calling for the new facility to be in operation by the second half of 1958.

The new plant will be built for an annual capacity of 27 million pounds and designed to permit a further expansion of as much as 100 percent. The decision

For more data on advertised products, use Readers' Service Cards, last page.

No. 1 on the List

for small forged steel gate valve jobs



CHAPMAN LIST 960

You'll find more Chapman List 960 valves on more jobs than other small forged steel gate valves. For standing up and keeping maintenance costs down it's tops, by far, on the valve man's preference list. The reasons are sound and several.

Wedge gate faces are super hard . . . hardened to 800 Brinell by Chapman's exclusive Malcomizing process. They won't . . . *they can't* seize or gall. Easily replaceable seat rings are hardened stainless steel. Wear on seating surfaces is brought to a minimum. Bolted follower on the outside screw rising stem type has no exposed threads on its yoke . . . nothing that's easy to corrode.

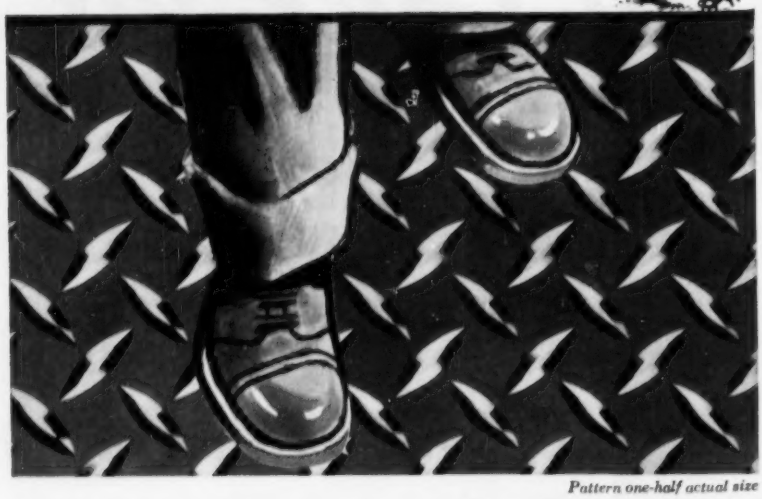
Made to take . . . and stand up under . . . pressures from 380 psi at 1000° F. to 2000 psi at 100° F. (For higher ratings use Chapman List 990 valves.) Sizes from $\frac{1}{4}''$ to $2''$ in many different alloys. You can have either rising stem with yoke or rising stem with inside screw. And, depending upon your needs, the Bonnet joint is either ground metal-to-metal or gasketed.

Catalog 10 has full information. It's required reading for men interested in valves. Write for your copy today.

THE CHAPMAN VALVE MANUFACTURING CO.
INDIAN ORCHARD, MASSACHUSETTS

For more data on advertised products, use Readers' Service Cards, last page.

Crampons prevent slipping on mountain ice, but



Pattern one-half actual size

every step is a SAFE step on low cost A.W. SUPER-DIAMOND

ECONOMY ROLLED STEEL FLOOR PLATE

Where foot safety—with economy—is a *must*, specify A.W. SUPER-DIAMOND. Secrets of SUPER-DIAMOND's anti-slip protection are the raised diamond-shaped steel figures. Alternately spaced at right angles and correct distances, these raised figures provide safe, foot-gripping friction from any angle of approach.

SUPER-DIAMOND is tough, rolled steel floor plate—can be fabricated with ordinary shop equipment—presents no matching or waste problems—cleans and drains rapidly. Use it structurally, as an overlay or complete flooring.

No other floor plate can match A.W. SUPER-DIAMOND'S *safety, durability and easy maintenance at so low a cost.*

A.W. SUPER-DIAMOND
ROLLED STEEL FLOOR PLATE

"The diamond in the rough . . . a gem of a flooring."

ALAN WOOD STEEL COMPANY
Conshohocken, Pa.

Please send A.W. SUPER-DIAMOND Booklet SD-8

Name_____
Title_____
Company_____
Address_____
City_____ Zone_____ State_____

Other products: A.W. ALGRIP Abrasive Rolled Steel Floor Plate—Plates—Sheets—Strip—(Alloy and Special Grades)

For plants where oil, water and grease raise special problems of slipping accidents, we suggest a check on the special qualities of A.W. ALGRIP . . . the world's only abrasive rolled steel flooring.

Who's Building . . .

to build an acrylic-fiber plant came after the announcement that American Cyanamid would expand production of acrylonitrile at its Fortier plant near New Orleans.

Humble Oil & Refining Company will add a third unit to the catalytic-cracking capacity of its 282,000-barrel-a-day refinery at Baytown, Texas. The new cracker, due to be completed in about 18 months, will have a daily capacity of 55,000 barrels. The refinery's two existing catalytic crackers are of similar capacities.

B. A. Shawinigan, Ltd., is expanding its plant at Montreal East to increase the production of phenol by 50 percent. Work on the expansion has been started, and the project is scheduled for completion in early 1957.

The Dow Chemical Company has exercised its option to purchase a 1700-acre tract along the Mississippi River between Baton Rouge and Plaquemine, La. The tract will be used as the site for a $20-million plant which is expected to turn out a number of organic chemicals.

The Texas Company has started up a new catalytic-reforming unit at its 17,000-barrel-a-day refinery at Casper, Wyo. The unit, a 4800-barrel-a-day Platformer, was engineered and constructed by The Fluor Corporation, Ltd.

The tenth new catalytic reformer to be installed at Texaco refineries under a $72-million expansion program, the unit brings the company's total reforming capacity to 105,500 barrels a day.

The British American Oil Company, Ltd., has awarded the contract for construction of new crude-processing facilities at its Clarkson, Ont., refinery. The new facilities, to be installed by The Canadian Kellogg Company, Ltd., will add some 40,000 barrels a day to the refinery's present 21,500-barrel-a-day capacity.

The new crude-distillation equipment, which is expected to cost about $5,500,000, is in addition to the 10,000-barrel-a-day catalytic-reforming unit under construction at Clarkson. This expansion is part of the company's estimated $56-million budget for 1956.

Denver Research Institute has awarded a contract to Stearns-Roger Manufacturing Company for construction of a shale-oil pilot plant which will develop a process developed by Aspengren & Company of Stockholm.

The Swedish firm has granted U. S. rights to its process to Oil Shale Corporation, a Los Angeles concern, which signed a $250,000 contract in January with Denver Research Institute to experiment with the process. *(See* PETROLEUM REFINER, *February 1956, page 187.)*

The plant, to be built in Denver, will process a ton of shale an hour. The research institute has been operating a pre-pilot-plant model in its laboratories. It has a capacity of 300 pounds of oil shale an hour.

Odessa Butadiene Company has awarded the contract for design, engineering and construction of its proposed butadiene plant near Odessa, Texas. The

You pick the place... we'll put the plant on it.

IN fact, McKee's fifty years of experience in designing and building plants for major industries can be a valuable help to you in selecting the site.

And McKee can undertake the entire project from preliminary studies to completed plant, ready for initial operation, under a *single contract.*

You'll find physical evidence of the excellence of McKee engineering and construction in successfully operating plants all over the world. If you want your new plant designed and built to earn a profit *call in McKee.*

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Who's Building...

contract, which went to The Fluor Corporation, Ltd., calls for an installation to produce about 50,000 tons a year of butadiene.

Construction will be started in midsummer and is scheduled to be completed in 1957. Facilities will include a dehydrogenation section using the Houdry process to convert butane to butadiene and a purification section using the Esso C. A. A. process.

International Synthetic Rubber Company, Ltd., is a new British company organized to build a synthetic-rubber plant with an annual capacity of 40,000 to 50,000 tons a year. The plant, to be near Southampton, will be completed in 1957.

It will be owned by two U. S. concerns, Firestone Tire & Rubber Company and The Goodyear Tire & Rubber Company; a British company, Dunlop Rubber Company, Ltd., and a French manufacturer, Compagnie General des Establissements Michelin.

The Standard Oil Company (Ohio) is due to start construction increasing capacity of its Elmore, Okla., gasoline plant from 14 to 35 Mmcf. a day. The project will increase the plant's output from 7000 to 10,000 gallons of natural gasoline a day.

Lake Charles Chemical Corporation, a new company planning to build a delayed-coking and calcining unit at Lake Charles, has awarded The Fluor Corporation, Ltd., a contract to handle engineering and construction.

The unit, planned for a daily capacity of 10,000 barrels, will be built adjacent to Continental Oil Company's Lake Charles refinery, and it will be operated as an integrated part of the refinery.

The project, to be started in September, will take about a year to complete. It is expected to cost a total of $6,250,000.

Coking equipment will consist of a fractionator, heater, coke drums, gas compressor and auxiliaries, together with decoking equipment, dewatering and coke-storage areas, and facilities for moving coke.

Included in the calcining unit will be a coke crusher, raw-coke feed hopper, rotary calciner, cooler, dust collector, conveyor system and storage silos.

Cities Service Oil Company, which will operate a natural-gasoline plant to be built on the Roberts Ranch in Midland County, Texas, has announced that the contract for construction went to Delta Engineering Company.

Lease holders on the ranch are joining in construction of the plant, which ultimately will process 50 Mmcf. of gas a day, turning out some 225,000 gallons of natural-gas liquids. Initially, the plant will operate at a capacity of 25 Mmcf. a day.

Potasse & Engrais Chimiques (P. E. C.) has awarded the contract for design and construction of an ammonium-nitrate granulation plant at Grand-Couronne. The French company picked a Belgian concern, Societe Belge de L'Azote et des Produits Chimiques du Marly (S. B. A.) to do the work. The granulation plant will be based on a process developed by S. B. A.

The M. W. Kellogg Company is the second company to acquire the site to build a plant in the petrochemical center Phillips Petroleum Company is developing on the Houston Ship Channel. The other company is Celanese Corporation of America.

Both companies are planning units for the manufacture of polyolefin plastics, and Celanese already has started construction on facilities to turn out nearly 40,000 pounds a year of polyolefin resins.

Each of the companies has entered a licensing agreement with Phillips looking toward production of plastics by a Phillips-owned process. In addition, Phillips will provide ethylene as a raw material to the Celanese plant.

Phillips bought 950 acres on the ship channel to subdivide and sell to other companies as plant sites. The company is hoping to spur development of the area into a center of petrochemical manufacturing.

Construction and design of the Celanese plant is being handled by C F Braun & Company. It is due to be completed in 1957.

Chemoil Corporation is a new company planning to build a refinery of some 20,000-barrel-a-day capacity near New Orleans. Construction of the plant, expected to cost about $20 million, is due to start in 18 months.

Petrochemicals, Ltd., a Royal Dutch/Shell Group affiliate, has started work on extension of its Partington, England, plant. New facilities, expected to be in full operation by mid-1958, will include a plant for making about 25,000 tons of ethylene oxide a year.

The plant will use a process worked out by Shell Development Company in the U. S. for direct catalytic oxidation of ethylene.

A new plant for converting ethylene oxide to ethanolamines went into operation at Partington early this year, and additional capacity for glycol ether, polyglycols and non-ionic surface-active agents is under construction.

When the direct oxidation plant is completed, the existing ethylene-oxide plant will be used to expand the company's production of propylene oxide.

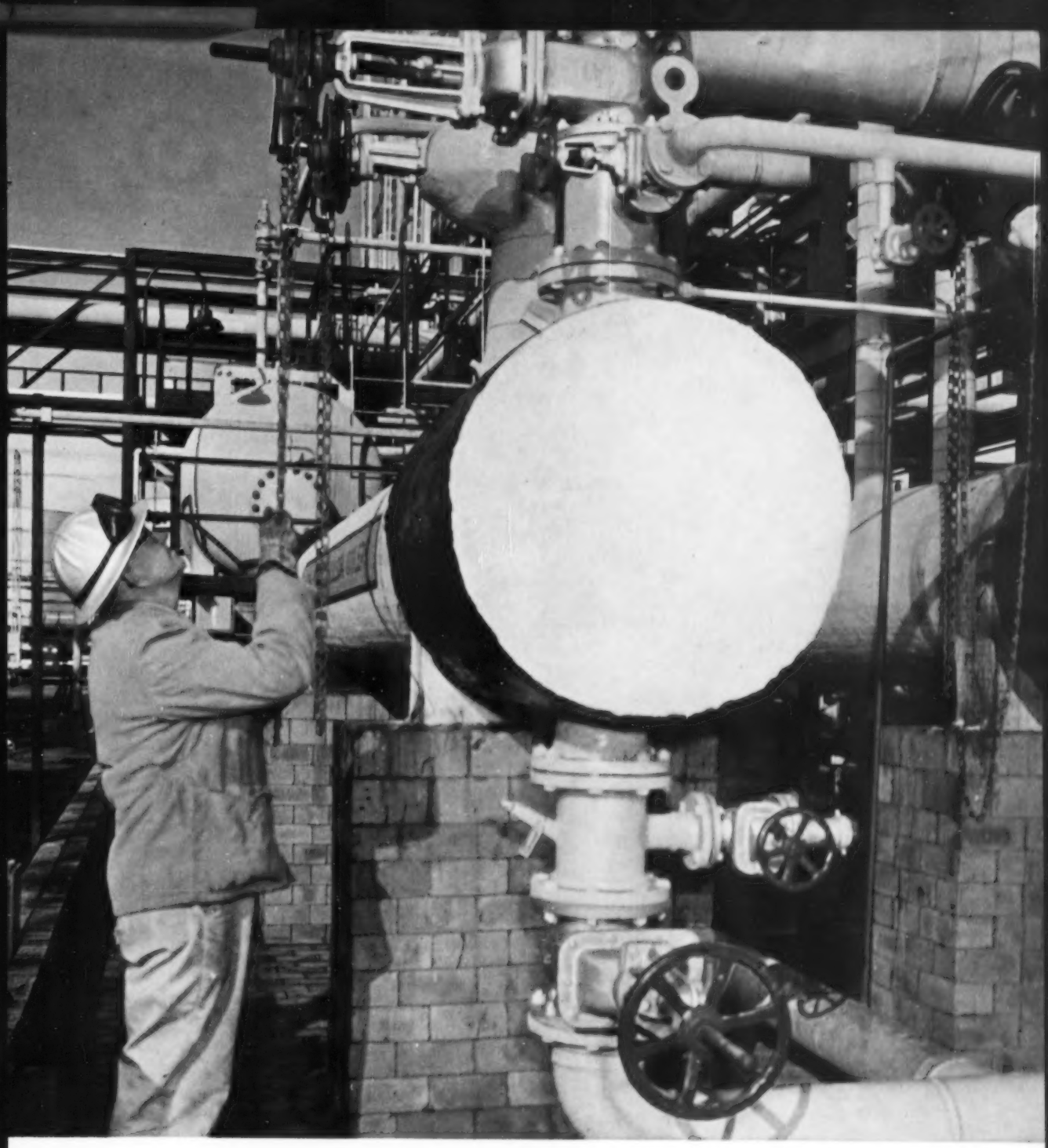
Esso Research and Engineering Company is to build three new structures, one of them a five-story office building, at its research center in Linden, N. J. The other two buildings will be a garage for company vehicles and a storehouse.

Construction BOX SCORE

REFINERIES, NATURAL GASOLINE AND PETROCHEMICAL PLANTS

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
Air Reduction	Calvert City, Ky.	Oxygen Plt.			Complete				
		Vinyl Acetate, Monomer Plt.			Complete				
*American Cyanamid	Northern Florida	Acrylic Fiber	27,000,000 bbls/yr.		Planning	1958			
American Oil Co.	Yorktown, Va.	Refinery: Two-Stage Distillation; Cat Crk.; Polymerization; Hydrodesulfurization; Coking; Ultraforming	35,000 bbls.	$30,000,000	Under Constr.	Nov., 1956	Std. (Ind.)	Kellogg, Lummus, Parsons	Kellogg, Lummus, Parsons, CB&I
*American Synthetic Rubber	Louisville, Ky.	Exp. Copolymer Plt.	To 68,000 tons/yr.		Under Constr.	1st. Qtr., 1957		Kidde	Kidde
Ashland Oil & Refining Co.	Catlettsburg, Ky.	Crude Expan.	20,000 bbls.	$1,500,000	Under Constr.	Sept., 1956			Procon
Atlantic Refining	Philadelphia	Cat. Cracker	32,000 bbls.	$3,500,000	Under Constr.	Sept., 1956	UOP	Procon	Procon
		Cat. Reforming	15,000 bbls.	Part of $11,000,000 Program	Engineering	Mid 1957	Atlantic	Blaw Knox	Blaw Knox
		Inc. Ammonia Cap.	175 tons		Engineering				
Atlantic Refining	Philadelphia	Jet-fuel Blending		$450,000	ODM Approved				
*California Oil	Perth Amboy, N.J.	Inc Reforming			Planning			Bechtel	Bechtel
Commerce Oil Ref.	Portsmouth, R.I	Refinery, Cat. Cracking Crude Units	30,000 bbls. 25,000 bbls. 40,000 bbls.	$30,000,000	Planning	1957		Lummus	

Construction Boxscore Continued on Page 235



Closing the gate on hard-to-hold hydrocarbons

At Esso Standard Oil's Bayway Refinery light hydrocarbons are used extensively at a wide range of temperatures and pressures.

Light hydrocarbons are hard to "hold," but the self-adjusting wedge design on Aloyco gate valves insures tight shut-off. Corrosion-resistant Aloyco valves — like the red-wheeled, chain-operated gate valve above — are used throughout many process units.

You'll see many more of them on key jobs at leading petroleum, processing and chemical plants throughout the country. What about your corrosives-handling problems? Write Alloy Steel Products Company, Inc., 1301 West Elizabeth Avenue, Linden, New Jersey.

62

Subsidiary of Walworth Company

FAST REPLACEMENT

When a refinery has to shut down for a replacement or repair—that's the time when action and know-how count.

The special spiral fin unit here shown had to be built over a week-end to get a large oil refining plant back on stream.

Such repair and replacement work has added to the fine reputation Sun Ship has won through years of service in the construction of oil refining and chemical equipment of every kind.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE SINCE 1916 CHESTER, PA.

For more data on advertised products, use Readers' Service Cards, last page.

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Escambia Bay Chemical Corp.	Pensacola, Fla.	Ammonia, Nitrogenous Fertilizer Plt.	.....	$25,000,000	Complete	.....	.....	.....	Chemico
Escambia Bay Chemical	Pensacola, Fla.	Polyvinyl-Chloride Resin	30,000,000 lbs./yr.	$3,100,000	Under Constr.	Late 1956	.....	Blaw Knox	Blaw Knox
*Esso Standard	Everett, Mass.	Powerformer	7,200 bbls.	.....	Under Constr.	Mid 1957	Esso	Badger	Badger
Esso Standard Oil Co.	Linden, N.J.	Convert Blending Syst. to Semi-Automatic	.....	$2,120,000	Complete	.....	Esso R&E	Esso R&E	Staff
Esso Standard	Linden, N. J.	Hydroformer	20,000 bbls.	.....	Under Constr.	3rd Qtr. 1956	Esso R&E	Foster Wheeler	Foster Wheeler
Esso Standard	Linden, N.J.	Ethylene Plt.	.....	.....	Under Constr.	.....	.....	S&W Badger Div.	S&W Badger Div.
Frontier Oil Refining	Tonawanda, N.Y.	Cat. Reformer	6,000 bbls.	$2,000,000	Under Constr	Oct., 1956	.....	Blaw Knox	Blaw Knox
General Aniline & Film	Linden, N.J.	Ethylene Oxide; Ethylene Glycol	.....	$8,000,000	Engineering	1957	SDC	SDC	.....
B. F. Goodrich	Louisville, Ky.	Syn. Rubber	.....	$2,500,000	Complete	.....	.....	Staff, Girdler	Girdler
Gulf Oil	Philadelphia	Visbreaker	22,500 bbls.	$2,500,000	Complete	.....	.....	Staff	Catalytic
		Cat. Reforming	24,000 bbls.	.....	Engineering	Mid 1957	UOP	Procon	Procon
		LPG	1,000 bbls.	.....	Under Constr.	Late 1956	.....	Gulf	.....
Gulf Oil	Philadelphia	Alkylation	2,800 bbls.	.....	Under Constr.	Late 1956	.....	Parsons	Parsons
Hercules Powder	Parlin, N.J.	Gulfining	36,000 bbls.	.....	Under Constr.	Early, 1957	Gulf	Gulf, Kellogg	Kellogg
		Polyethylene	30,000,000 lbs./yr.	$10,000,000	Under Constr.	.....	.....	.....	.....
Heyden Chemical	Fords, N.J.	Pentaerythritol	25,000,000 lbs./yr.	.....	Under Constr.	March, 1957	.....	.....	.....
Kentucky Hydro-carbon	Maytown, Ky.	Ethane Plt.	50 Mmcf	.....	Designing	Early 1957	.....	.....	.....
Ketrona Chemical	Tarrant, Ala.	Ammonia Nitric Acid Nitrate of Ammonia Plt.	.....	.....	Complete	.....	.....	Fluor	Fluor
*Koppers	Woodbridge, N.J.	Polyethylene	30,000,000 bbls./yr.	.....	Under Constr.	Early 1957	Koppers	Koppers	Koppers
Monsanto Chemical	Springfield, Mass.	Inc. Polyvinyl Chloride Resins Cap.,	26,000,000 lbs./yr.	$2,000,000	Complete	.....	.....	Staff	.....
Northern Chemical Industries	Searsport, Me.	Nitric Acid Plt.	60 ton/yr.	.....	Planning	1956	.....	Fluor	Fluor
		Ammonia	125 tons					Fluor	Fluor
		Nitric Acid	60 tons	$9,000,000	Complete	.....	Texaco	Girdler	Girdler
		Nitrogen Solutions	.....				Du Pont	Girdler	Girdler
							.....	Girdler	Girdler
Pennsalt	Calvert City, Ky.	Organic-Fluorine	.....	.....	Planning	1956	.....	.....	.....
Petroleum Separating	Bayonne, N.J.	Crude Skimming	15,000 bbls.	.....	Complete	.....	.....	.....	.....
Pontiac Eastern Corp.	Hattiesburg, Miss.	Refinery	12,000 bbls.	$18,000,000	Under Constr.	May, 1957	U.O.P.	Fluor	Treco
Procter & Gamble Mfg. Co.	Chicago, Ill.	Hydrogen Plt.	.....	.....	Under Constr.	Sept., 1956	.....	Girdler	Fluor
Reichhold Chemical	Tuscaloosa, Ala.	Sulfuric Acid Plt.	100 tons/day	$1,000,000	Planning	.....	.....	Girdler	Girdler
Seminole Oil	Fort Pierce, Fla.	Refinery	15,000 bbls.	$16,000,000	Planning	.....	.....	.....	.....
Sinclair Refining Co.	Marcus Hook, Pa.	Crude Stills	120,000 bbls.	$12,700,000	Complete	.....	U.O.P.	Ebasco	.....
Socony Mobil	Paulsboro, N.J.	Hydrodesulfurization	22,000 bbls.	.....	Under Constr.	March, 1957	Sinclair	Parsons	Parsons
							.....	Foster Wheeler	Foster Wheeler
Socony-Mobil	Paulsboro, N.J.	Sovaformer	22,000 bbls.	.....	Complete	.....	.....	.....	.....
Socony Mobil	Brooklyn	Sovaformer	.....	.....	Under Constr.	Oct., 1956	.....	Foster Wheeler	Foster Wheeler
Socony Mobil	Buffalo, N. Y.	Sovaformer	9,000 bbls.	.....	Completing	.....	.....	Bechtel	Bechtel
Southern Nitrogen	Savannah, Ga.	Ammonia, Nitric Acid, Nitrogen Solutions, Ammonium Nitrate, Urea	250 ton	$14,000,000	Under Constr.	Jan., 1957	.....	McKee Girdler	McKee Girdler
Spencer Chemical	Vicksburg, Miss.	Addl. Nitrogen	.....	$1,500,000	Complete	.....	.....	Staff	Quaker
Stauffer Chemical	Louisville, Ky.	Carbon Tetrachloride, Chloroform, Methylene Chloride, Hydrogen Chloride	.....	.....	Under Constr.	1957	.....	.....	.....
*Stauffer Chemical	La Moyne, Ala.	Sulfur Recovery	.....	.....	Under Constr.	.....	.....	Parsons	Parsons
Stauffer Chemical	Mobile, Ala.	Carbon Bisulfide Plt.	.....	.....	Under Constr.	1956	.....	Stauffer	Parsons
The Texas Co.	Westville, N.J.	Hydrotreater	6,500 bbls.	$800,000	Under Constr.	Sept., 1956	.....	Treco	Treco
The Texas Co.	Westville, N.J.	Vis-Breaker	13,300 bbls.	$1,300,000	Engineering	Oct., 1956	.....	Treco	Treco
		Inc. FCC Cap.	6,500 bbls.	.....	Under Constr.	4th Qtr., 1956	.....	.....	.....
		Inc. Vacuum Pipe Shell Cap.	10,000 bbls.	$1,000,000	Under Constr.	4th Qtr., 1956	.....	Staff	Catalytic
Thompson Chem.	North Dighton, Mass.	Polyvinyl Chloride Plt.	.....	.....	Planning	.....	SDC	SDC	.....
Tide Water Oil	Wilmington, Del.	Refinery	130,000 bbls	$100,000,000	Under Constr.	End, 1956	.....	Braun, Kellogg	.....
*United Refining	Warren, Pa.	FCC Gas Recovery; Cat Poly; Treating	2,500 bbls.	.....	Under Constr.	4th Qtr. 1956	.....	Procon	Procon
MID-CONTINENT									
Allied Chemical & Dye	Toledo, Ohio	Polyester	.....	.....	Engineering	.....	.....	Catalytic	Catalytic
*Anderson-Prichard	Cyril, Okla.	Cat. Crker, Fractionation; Light-Ends Recovery; Revamping	5,000 bbls.	.....	Under Constr.	March, 1957	UOP	Procon	Procon
Calumet Nitrogen Products Co.	Hammond, Ind.	Ammonia Nitrogen Fertiliser	300 Tons	.....	Complete	.....	.....	Fluor	Fluor
*Century Refining	Garden City, Kans.	Cat Reformer	500 bbls.	$150,000	Engineering	Jan., 1957	UOP	Litwin	Staff
Cities Service	Ponca City, Okla.	Rexformer	6,000 bbls.	.....	Engineering	Jan., 1957	UOP	UOP	Procon
Cities Service	Wichita, Kans.	Revamp Gasc. Plt.	.....	.....	Complete	.....	.....	.....	.....
Cities Service Oil	Ponca City, Okla.	Increase Ref.	10,000 bbls.	$2,000,000	Engineering	.....	.....	.....	.....
*Continental Oil	Ponca City	Cat Reformer	11,000 bbls.	$3,000,000	Under Constr.	Mid 1957	.....	Kellogg	Kellogg
Cooperative Refinery	Coffeyville, Kan.	Revamp Cat. Cracker	8,500 bbls.	$1,200,000	Complete	.....	UOP	Treco	Treco
Cooperative Refinery	Coffeyville, Kans.	Platformer	5000 bbls.	$850,000	Complete	.....	UOP	SWECO	SWECO
		Unifiner	3000 bbls.	$450,000	Complete	.....	UOP	SWECO	SWECO
Derby Refining	Wichita, Kan.	Delayed Coker	8,440 bbls.	$1,250,000	Complete	.....	UOP	Treco	Treco
		Hydrodesulfurization	.....	.....	Completing	.....	.....	.....	.....
		Revamp Crude	25,000 bbls.	$45,000	Under Constr.	April, 1957	.....	Litwin	Staff

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Derby Oil	Wichita, Kans.	Ultraformer	2500 bbls.	.....	Complete	.....	Standard-Ind.	.....	Pritchard
Dow Chemical	Pevely, Mo.	Polystyrene Plt.	.....	.....	Under Constr.	Fall, 1956	.....	.....	.....
*D-X Sunray	Duncan, Okla.	Inc. Cat. Reformer	†3,000 bbls.	.....					
		Pretreater	8,000 bbls.	.....	Planning	Fall 1957	.....	.....	.....
		Hydrogenation	10,800 bbls.	.....					
*D-X Sunray	Tulsa	Cat Reformer	12,000 bbls.	.....					
		Hydrogenation	12,000 bbls.	.....					
		Alkylation	2,500 bbls.	.....	Under Constr.	.....	.....	.....	.....
		Butane-Isomerization	1,500 bbls.	.....					
Firestone Tire	Akron, Ohio	Expand Syn. Rubber Plt.	†35 percent	.....	Planning	.....	.....	.....	.....
*Goodrich Chemical	Avon Lake, Ohio	Add. Polyvinyl Resins, Plastic Compounds	.....	$8,000,000	Under Constr.	March, 1957	.....	Girdler	Girdler
Goodyear Synthetic Rubber	Akron, Ohio	Copolymer Exp.	27,000 tons/yr.	$2,500,000	Planning	Jan., 1957	.....	.....	.....
Hercules Powder	Louisiana, Mo.	Formaldehyde Plt.	100,000,000 lbs./yr.	.....	Under Constr.	Late 1956	.....	.....	.....
		Pentaerythritol Plt.	24,000,000 lbs./yr.	.....	Under Constr.	Late 1956	.....	.....	.....
Hercules Powder	Louisiana, Mo.	Methanol Plt.	7,000,000 gal./yr.	$2,000,000	Planning	.....	.....	.....	.....
Indiana Farm Bureau Coop.	Mt. Vernon, Ind.	Platformer	3,000 bbls.	.....	Under Constr.	Aug., 1956	UOP	Sweco	Sweco
		Unifiner	2,100 bbls.	.....	Under Constr.	Aug., 1956	UOP	Sweco	Sweco
International Refineries	Wrenschall, Minn.	Cat. Reformer	2,800 bbls.	$1,500,000	Under Constr.	Fall, 1956	Esso	Parsons	Parsons
*Lakeside Refining	Kalamazoo, Mich.	Cat Reformer	1,000 bbls.	$200,000	Under Constr.	Aug., 1956	.....	Litwin	Staff
Leonard Refineries	Alma, Mich.	Cap. Increase	14,000 bbls.	.....	Under Constr.	.....	.....	.....	.....
Leonard Refineries	Alma, Mich.	Ultraformer	3,600 bbls.	.....	Under Constr.	.....	Std. (Ind.)	Parsons	Parsons
		Hydrofiner	5,200 bbls.	.....	Under Constr.	.....	.....	Pritchard	Pritchard
*Mid-America Refining	Chanute, Kans.	Crude & Cracking Unit Revamp	.....	$50,000	Under Constr.	Aug., 1956	.....	Litwin	Staff
Midland Co-op	Cushing, Okla.	Platformer	3000 bbls.	$650,000	Complete	.....	UOP	UOP	Procon
Naph-Sol Refining Co.	Muskegon, Mich.	Cat. Reformer	6,000 bbls.	.....	Planned	.....	.....	.....	.....
National Cooperatives	McPherson, Kans.	Alkylation	1400 bbls.	$1,200,000	Under Constr.	Oct., 1956	UOP	Treco	Treco
*National Petrochemical	Tuscola, Ill.	Mod. Ethylene Unit	.....	.....	Under Constr.	1957	.....	S&W Badger Div.	.....
Olin Mathieson	Olin, Ind.	Cellophane Plt.	.....	.....	.....	1956	.....	.....	.....
Pana Refining Co.	Pana, Ill.	Modernization	†1,600 bbls.	$900,000	.....	.....	.....	.....	.....
*Petroleum Specialties	Flat Rock, Mich.	Visbreaker	3,000 bbls.	$250,000	Planning	.....	.....	.....	.....
Phillips Petroleum	Kansas City	Expan. Lube Plt.	20 percent	.....	Under Constr.	Fall 1956	.....	Litwin	.....
Phillips Petroleum	Kansas City, Kansas	Catalytic Reformer	16,000 bbls.	$5,400,000	Complete	.....	U.O.P.	Procon, Phillips	Procon
Prime Oil Co.	Calumet City, Ill.	Refinery	15,000 bbls.	$10,000,000	Planned	.....	.....	.....	.....
Procter & Gamble	Kansas City, Kan.	Hydrogen Plt.	.....	.....	Engineering	1st Qtr., 1957	.....	Girdler	Girdler
The Pure Oil Co.	Lemont, Ill.	Cat. Reformer	.....	.....	Planning	.....	.....	.....	.....
R&J O&R	Princeton, Ind.	Thermal Poly	1800 bbls.	.....	Planning	.....	.....	UOP	.....
Signal Oil & Gas	Healdton, Okla.	Plt. Additions	.....	$1,000,000	Under Constr.	Aug., 1956	.....	Hudson	.....
Sinclair Refining Co.	E. Chicago, Ind.	Crude Unit	.....	.....	Complete	.....	.....	.....	.....
*Socony Mobil	East St. Louis	Sovaformer	12,000 bbls.	.....	Planning	Early, 1957	.....	Fluor	Fluor
		Pretreater	16,000 bbls.	.....	Planning	Early, 1957	.....	Fluor	Fluor
Socony Mobil	E. Chicago, Ind.	Sovaformer	9,000 bbls.	.....	Complete	.....	.....	Braun	Braun
Socony Mobil	Trenton, Mich.	Sovaformer	.....	.....	Complete	.....	.....	Bechtel	Bechtel
Socony Mobil	East Chicago, Ind.	Alkylation	.....	.....	Complete	.....	.....	Kellogg	Braun
*Standard-Indiana	Whiting, Ind.	Crude Unit	30,000 bbls.	.....	Complete	.....	.....	.....	.....
		Ultraformer No. 2	21,000 bbls.	.....	Under Constr.	.....	Std. (Ind.)	Parsons	Parsons
Standard Indiana	Whiting, Ind.	Dewaxing	5,000 bbls.	.....	.....	.....	.....	.....	.....
Standard-Indiana	Whiting, Ind.	Ultraformer	14,000 bbls.	.....	Complete	.....	Standard-Ind.	Foster Wheeler	Foster Wheeler
Standard-Indiana	Wood River, Ill.	Coking Unit	8,500 bbls.	.....	Planning	1957	.....	Parsons	Parsons
Standard-Indiana	Sugar Creek, Mo.	Alkylation	3,800 bbls.	.....	Under Constr.	Early, 1957	.....	Foster Wheeler	Foster Wheeler
*Standard (Ohio)	Toledo, Ohio	Refinery Exp.	†60,000 bbls.	$40,000,000	Engineering	Late 1957	.....	Kellogg	Kellogg
*Standard (Ohio)	Elmore, Okla.	Exp. Gasoline Plt.	†2k Mmcf	.....	Under Constr.	.....	.....	.....	.....
Standard (Ohio)	Cleveland, Ohio	Ultraformer	11,000 bbls.	$4,400,000	Complete	.....	Standard-Ind.	Fluor	Fluor
St. Paul Ammonia Products Co.	Pine Bend, Minn.	Ammonia Plt.	200 tons	$15,000,000	Complete	.....	Texaco	Lummus	Lummus
Sun Oil	Toledo, Ohio	Alkylation	1,300 bbls.	$1,200,000	Complete	.....	Texaco	Staff	Catalytic
Sunray-Midcontinent	Moore, Okla	Exp. Gaso. Plt.	.....	$275,000	Complete	.....	.....	Staff	.....
The Texas Co.	Lawrenceville, N.J.	Inc. Vacuum Pipe Still Cap.	8,500 bbls.	.....	Under Constr.	4th Qtr., 1956	.....	.....	.....
		Inc. FCC Cap.	2,000 bbls.	.....	Under Constr.	4th Qtr., 1956	.....	.....	.....
The Texas Co.	Lockport, Ill.	Alkylation Plt.	1,000 bbls.	.....	Complete	.....	.....	.....	.....
U. S. C. I.	Tuscola, Ill.	Isomer of Sebacic Acid	10,000,000 lb./yr.	.....	Under Constr.	.....	.....	Staff	McKee
Vickers Petroleum	Potwin, Kans.	Reformer	.....	.....	Planning	.....	.....	.....	.....
		Cat. Poly	.....	.....	Planning	.....	.....	.....	.....
Wisconsin Oil Refining Co.	Sheboygan, Wis.	Vacuum Unit	2,500 bbls.	.....	Planning	.....	.....	Koch	.....
SOUTHWEST									
*American Cyanamid	Avondale, La.	Acrylonitrile PH	.....	$25,000,000	Under Constr.	1958	.....	.....	.....
Arkansas Fuel Oil	Carthage, Texas	Reformer, Feed Preparation	900 bbls.	.....	Complete	.....	UOP	.....	Procon
Atlantic Refining	Pt. Arthur, Tex.	Catformer	15,000 bbls.	Part of $11,500,000 Program	Engineering	Mid 1957	Atlantic	Blaw-Knox	Blaw-Knox
*Atlantic Refining	Crane, Texas	Gasoline Plt.	25 Mmcf	.....	Engineering	.....	.....	.....	.....
Bureau-Mines	Exell, Texas	Helium Plt.	.....	$6,000,000	Planning	.....	.....	Stearns-Rogers	.....
Bay Petroleum	Chalmette, La.	Ref. Expan.	To 26,000 bbls.	$1,850,000	Complete	.....	.....	Bureau-Mines	.....
Carbide & Carbon	Seadrift, Texas	Ethylene Oxide Exp.	To 200,000,000 lbs./yr.	.....	Planning	.....	UOP	.....	.....
*Carbide & Carbon	Seadrift, Texas	Inc. Ethylene Glycol Cap.	To 65,000,000 lbs./yr.	.....	Planning	.....	.....	.....	.....
*Celanese	Houston	Polyolefin Refin	.....	.....	Licensed	1957	Phillips	.....	.....
*Celanese	Bishop, Texas	Plt. Expan.	25 Percent	.....	Under Constr.	.....	.....	.....	.....
Cities Service, et al	Midland, Texas	Nat. Gaso. Plt.	50 Mmcf	.....	Under Constr.	March, 1957	.....	Delta	Delta
Conden Pet.	Big Spring, Tex.	Rexformer	3900 bbls.	$2,500,000	Complete	.....	UOP	Procon	Procon
		Revamp Cat. Cracker	13,000 bbls.	$1,000,000	Under Constr.	Jan., 1957	UOP	Conden	Conden
		Styrene Plt.	20,000,000 lbs./yr.	$3,000,000	Under Constr.	Fall, 1956	.....	Badger Mfg.	Badger Mfg.

Construction Boxscore Continued on Page 238

BALDWIN-HILL MONO-BLOCK

helps cut down maintenance time on Esso Standard Oil Catalytic Cracker No. 1 at their Bayway Refinery

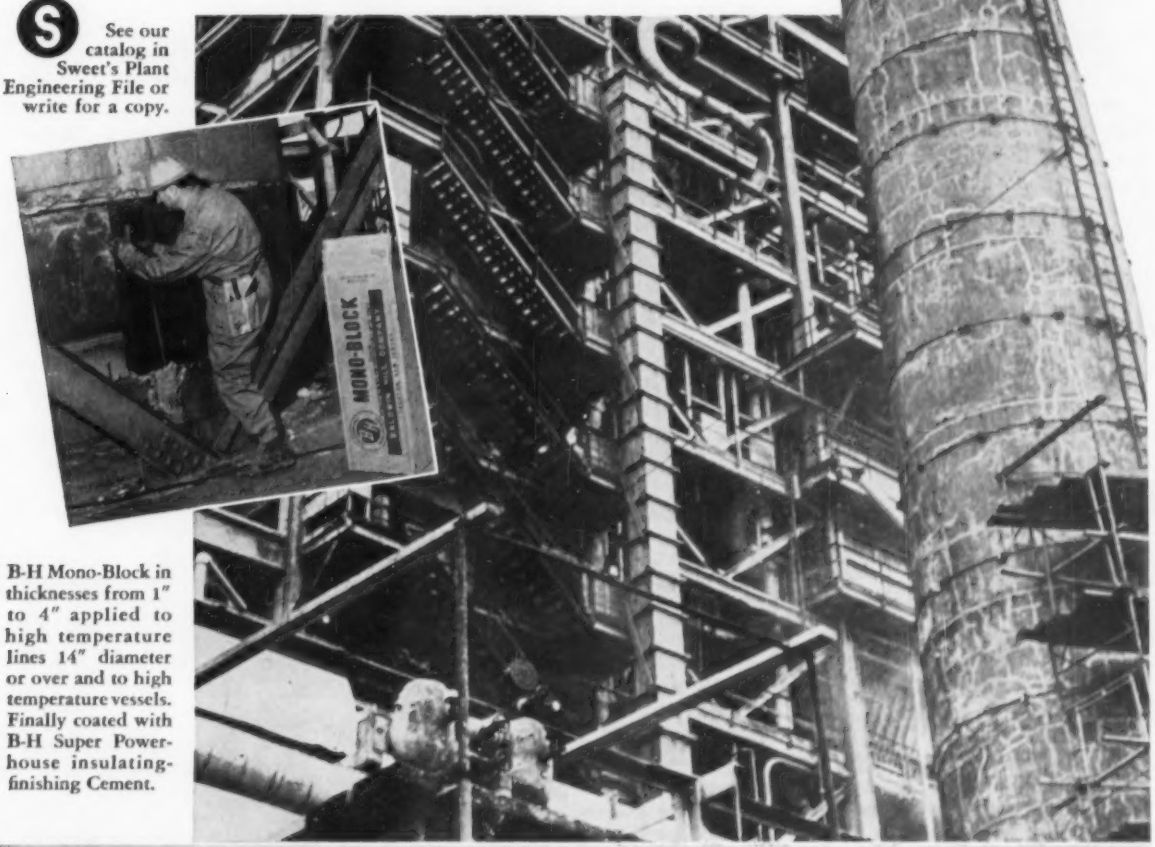
- The light weight, ease of handling, cutting and shaping speeds application of B-H Mono-Block.
- This one block covers the full range of temperatures up to 1700° F. No need for two insulating blocks for low and high temperatures.
- "Waffle" surface helps application of B-H Super Powerhouse insulating-finishing Cement without use of wire mesh base.
- Felted structure yields to surface projections and irregularities; easily impaled on studs.

BALDWIN-HILL COMPANY

707 Breunig Avenue, Trenton 2, N. J.

Huntington, Ind. Kalamazoo, Mich. Temple, Texas

S See our catalog in Sweet's Plant Engineering File or write for a copy.



B-H Mono-Block in thicknesses from 1" to 4" applied to high temperature lines 14" diameter or over and to high temperature vessels. Finally coated with B-H Super Powerhouse insulating-finishing Cement.

COMPLETE LINE OF BALDWIN-HILL INSULATING PRODUCTS

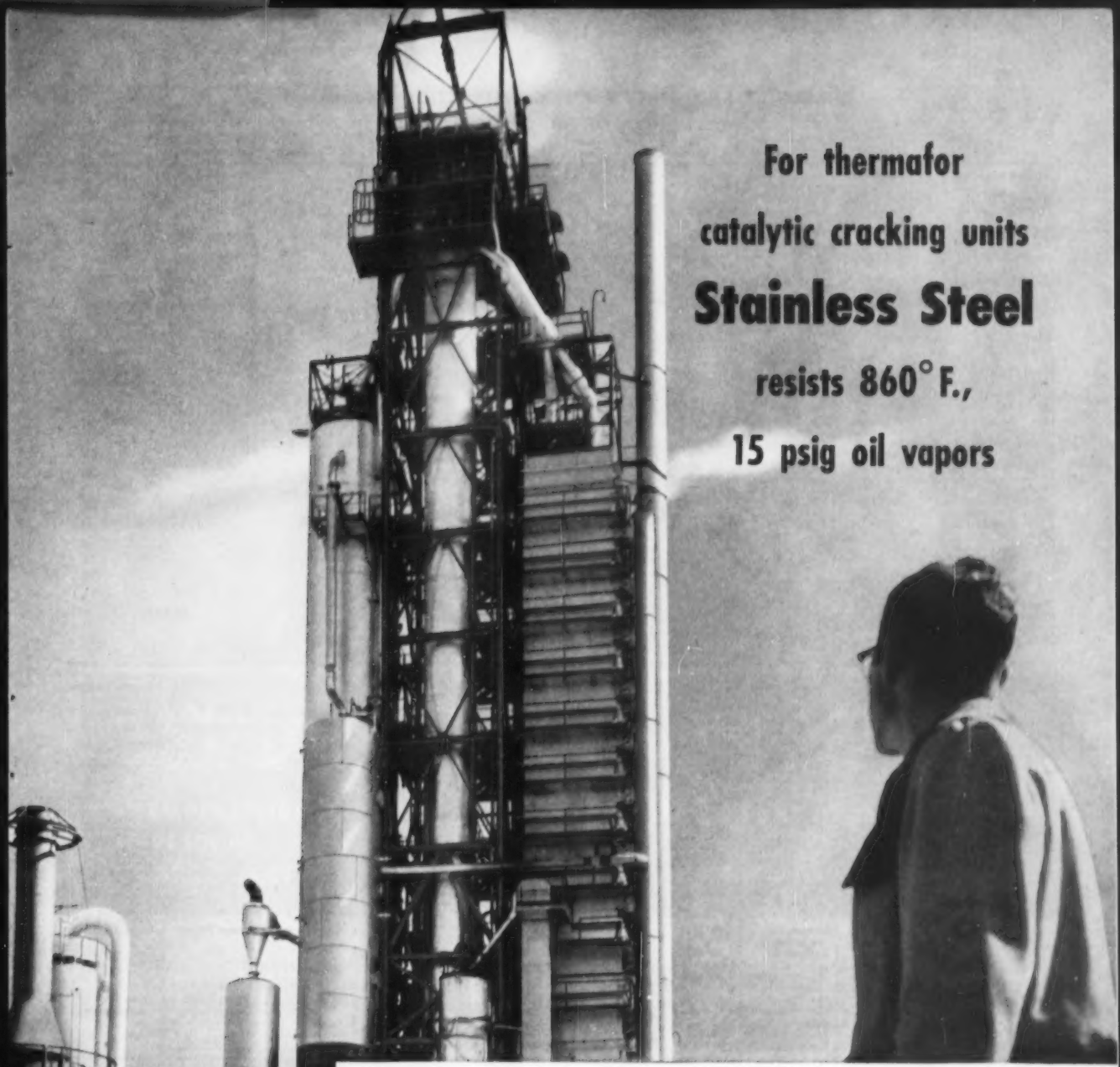
B-H Mono-Block	B-H Super Powerhouse Cement	B-H No. 100 Pipe Insulation
B-H Blanket	B-H No. 1 Insulating Cement	B-H 85% Magnesia Pipe Insulation
B-H Koldboard	B-H No. 52 Asbestos Cement	B-H Calcium Silicate Pipe Insulation
B-H Bond-Tite	B-H Spun Felt Insulation	B-H Mono-Kover Pipe Insulation
B-H Weatherseal	B-H Fine-Fyber Felt Insulation	B-H Spun Mineral Wool Fill

For more data on advertised products, use Readers' Service Cards, last page.

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Corpus Christi Refining Co.	Corpus Christi, Texas	Modernization & Expansion	†3,000 bbls.	$1,200,000	Under Constr.	.....	.....	.....	.....
*Delhi-Taylor Oil	Corpus Christi	Unifining Platforming	10,500 bbls.	.....	Planning	Early 1957	UOP	.....	.....
Diamond Alkali	Houston	Perchlorethylene Exp.	50 percent	.....	Under Constr.	.....	.....	.....	.....
*Dow Chemical	Baton Rouge	Organic Chemicals	.....	Part of $20,000,000	Planning	.....	.....	.....	.....
*Dow Chemical	Freeport, Texas	Acetylene, Methylacetylene, Ethanolamines, Synthetic Glycerine, Butadiene, Chlorine, Ethylene Oxide, Methyl Chloride, Glycerine, Glycol, Perchloro Ethylene and Styrene	.....	$45,000,000	Planned or Under Constr.	1958	.....	.....	.....
*Du Pont	Orange	Exp. Polyethylene Fac.	.....	.....	Planning	.....	.....	.....	.....
Eastern States Petroleum Co.	Houston, Texas	Coking Plt.	13,000 bbls.	$4,000,000	Projected	.....	.....	.....	.....
El Paso Natural Gas	Odessa, Texas	Butadiene	137 tons	$20,000,000	Designing	July, 1957	Houdry, Esso, Jasco	Fluor	Fluor
El Paso Natural Gas Products	El Paso, Texas	Alkylation Blending	.....	.....	Planning	.....	.....	.....	.....
*Esso Standard	Baton Rouge	Ethylene, Butadiene Expan.; Wax, Lube Oil, Avgas	.....	$40,000,000	.....	.....	.....	.....	.....
*Ethyl Corp.	Baton Rouge	Vinyl-Chloride Monomer Pet.	.....	.....	Under Constr.	Late 1957	.....	Cat Constr.	Cat. Constr.
Firestone	Orange, Texas	Butadiene Plt.	40,000 tons/yr.	.....	Engineering	Spring, 1957	Houdry, Esso	Cat. Constr.	Cat. Constr.
*Firestone	Orange	Styrene	75,000 ton/yr.	.....	Planning	Early 1958	.....	.....	.....
Firestone Tire	Lake Charles, La.	Expand Synth. Rubber Plt.	†150,000 ton/yr	.....	.....	.....	.....	.....	.....
General Petroleum	Lake Charles, La.	Anhydrous Ammonia	100,000 tons/yr.	$12,500,000	Engineering	Fall 1957	.....	.....	.....
General Tire	Odessa, Texas	Copolymer Plt.	40,000 ton/yr.	$8,000,000	Planning	July, 1957	.....	Fluor	Fluor
Goodyear Synthetic Rubber	Houston	Copolymer Expansion	200,000 tons/yr.	$9,000,000	Planning	Jan., 1957	.....	Blair Knox	.....
Grace Chemical	Baton Rouge, La.	Polyethylene	50,000,000 lbs./yr.	$18,000,000	Under Constr.	Mid 1957	Phillips	Fluor	Fluor
Gulf Natural Gas	Caddo Parish, La.	Gasoline Plt.	20 Mmcf	.....	Under Constr.	.....	.....	.....	.....
Gulf Oil	Port Arthur, Texas	Two Gulfiners	45,000 bbls.	.....	Under Constr.	Summer, 1956	Gulf	Gulf, Kellogg	Kellogg
Gulf Oil	Pt. Arthur, Tex.	Inc. Ethylene Fac.	.....	.....	Considering	.....	.....	.....	.....
Gulf Oil	Port Arthur, Texas	Incl. Alkylation Cap.	3,300 bbls.	.....	Under Constr.	Late 1956	.....	Gulf; Kellogg	Kellogg
		Polymerization Inc.	2,800 bbls.	.....	Under Constr.	.....	.....	Gulf; Procon	Procon
		Greasemaking; Packaging	.....	.....	Under Constr.	.....	.....	Summer Sollitt	Summer Sollitt
		Sludge Decomposer	125 tons	.....	Engineering	.....	Monsanto; Sonneborn	Leonard	Leonard
		Sulfur Recovery Inc.	60 tons	.....	Considering	.....	.....	.....	.....
J. M. Huber	Borger, Texas	Furnace Black	20-30,000,000 lbs./yr.	.....	Planning	.....	.....	.....	.....
*Humble	Baytown	Inc. Butadiene Cap.	16,000 ton/yr.	.....	Under Constr.	Early 1957	.....	.....	.....
Ingram Oil & Ref.	Meraux, La.	Cat Reformer	3,000 bbls.	$1,000,000	Complete	.....	U.O.P.	SWECO	SWECO
*Kellogg	Houston	Polyolefines	.....	.....	Licensed	Phillips	.....	.....	.....
Lake Charles Chemical	Lake Charles, La.	Coking, Calcining Unit	10,000 bbls.	$6,250,000	Planning	Sept., 1957	.....	Fluor	Fluor
Magnolia	Beaumont, Tex.	TCC Unit	27,800 bbls.	.....	Under Constr.	Late 1956	.....	Socony Mobil	Bechtel
		Sovaformer	20,000 bbls.	.....	Under Constr.	Late 1956	.....	Socony Mobil	Bechtel
Magnolia	Beaumont, Tex.	Light Hydrocarbon Fractionator	26,000 bbls.	.....	Complete	.....	.....	Owner & Fluor	Fluor
		Exp. Crude Distillation	15,000 bbls.	.....	Planning	Late 1956	.....	Owner & Bechtel	Bechtel
		Lube Blending & Packaging	.....	.....	Planning	Late 1956	.....	Owner & Summer Sollitt	.....
McBride Refining Co	Port Brownsville, Texas	Ref. Expan.	†2,500 bbls.	$2,500,000	Planned	.....	.....	.....	.....
MidSouth Chemical	Lake Charles, La.	Ammonia Plt.	.....	.....	Planning	.....	.....	.....	.....
Monsanto	Luling, La.	Adipic Acid	.....	.....	Under Constr.	Early 1957	.....	.....	.....
North American Petro.	Corpus Christi, Texas	Refinery	.....	$1,000,000	Under Constr.	.....	.....	.....	.....
Northeast Texas Chemical Co.	East Texas	Cat. Reformer	2,000 bbls.	.....	.....	.....	Atlantic	.....	.....
*Petroleum Chemicals	Lake Charles	Chemical and Fertilizer Plt.	.....	.....	Planning	.....	.....	Tears	Beck
Petroleum Chemicals	Lake Charles, La.	Anhydrone Ammonia	100,000 tons/yr.	$1,250,000	Under Constr.	Fall 1957	.....	.....	.....
Petro-Tex Chemical	Houston	Butadiene Plt., Expansion	†79,000 ton/yr.	$4,300,000	Under Constr.	Fall, 1956	.....	Fluor	Fluor
Phillips Pet.	Sweeny, Texas	Butadiene Expansion	†45,000 tons/yr.	$1,000,000	Under Constr.	Late 1956	.....	Bechtel	Bechtel
		Nat. Gas. Liquid Fractionation	30,000 bbls.	.....	Under Constr.	Fall 1956	.....	S&W Badger Div.	S&W Badger Div.
		H. F. Alkylation	2,000 bbls.	.....	Planning	Dec., 1956	.....	.....	.....
		Gas Cracking Facilities	5,500 bbls.	.....	Under Constr.	Spring, 1957	.....	.....	.....
Phillips Petroleum	Andrews, Texas	Nat. Gaso. Plt.	80 Mmcf	.....	Under Constr.	1956	.....	Phillips	Phillips; Gaso. Plt. Constr.
*Phillips Chemical	Andrews County, Texas	Sulfur Pet.	(tons	.....	Completing	.....	.....	.....	.....
Phillips Petroleum	Crane, Texas	Nat. Gaso. Plt.	50 Mmcf	.....	Under Constr.	1956	.....	Phillips	Phillips
Phillips Chemical	Gulf Coast	Carbon Black	64,000,000 lbs./yr.	.....	Planning	.....	.....	.....	.....
Phillips Chemical	Sweeny, Texas	Ethylene	329,000 lbs.	$12,357,000	Under Constr.	April, 1957	.....	Phillips; S&W Badger Div.	S&W, Badger Div.
Phillips Chemical	Pasadena, Texas	Polyethylene	301,000 lbs.	$31,525,000	Under Constr.	Aug., 1956	.....	Phillips	Farnsworth & Chambers
Phillips Chem.	Phillips, Texas	Exp. Copolymer Plt.	138 tons	.....	Under Constr.	July, 1957	.....	.....	.....

Construction Boxscore Continued on Page 240



For thermafor catalytic cracking units **Stainless Steel** resists 860° F., 15 psig oil vapors

How different refineries would be without Stainless Steel! And how much *more* they would cost to operate! Almost every time you find a high temperature, corrosive situation, you find lots of Stainless Steel.

In the unit shown here, the reactor chamber is lined with 7/64" type 410 Stainless. Reactor internals, bubble caps and trays and various vessel linings are also made from Stainless Steel. These are decisive steps to reduce the continuing high cost of refinery plant corrosion.

When *buying* Stainless Steel, remember that United States Steel offers the widest range of sizes, grades and types. Selection is easy, and you can be sure of service-tested USS quality.

El Dorado, Arkansas refinery of Lion Oil Company, a division of Monsanto Chemical Company.

SEE The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

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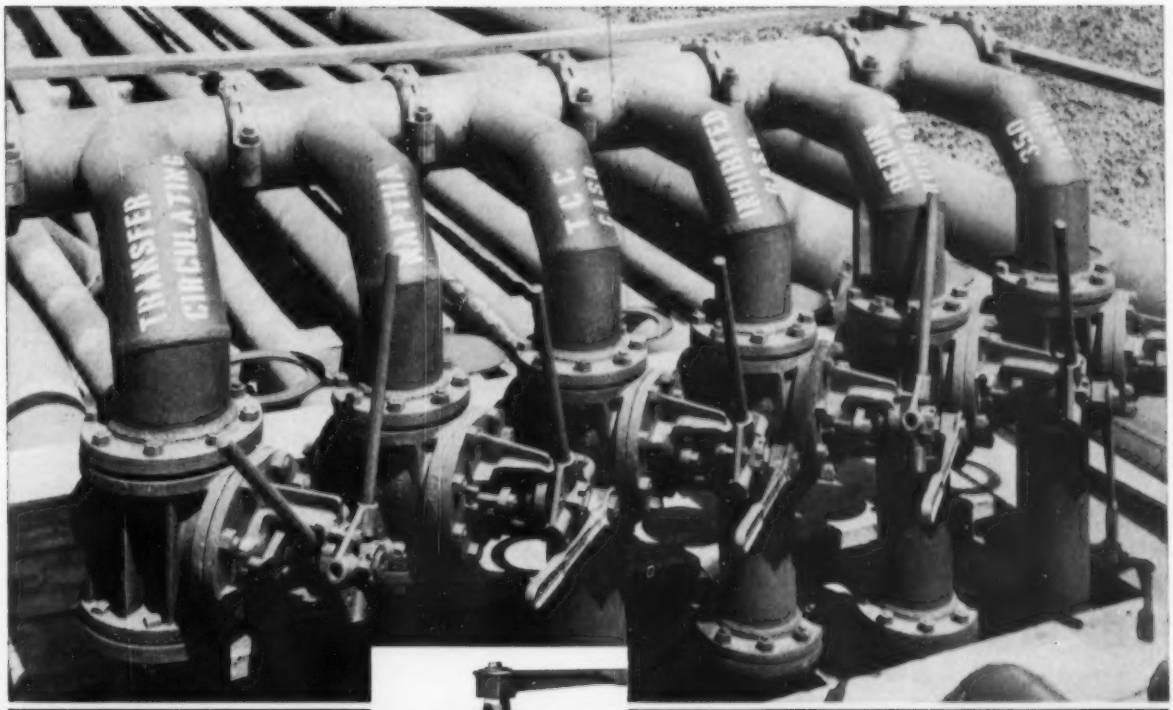
6-805

UNITED STATES STEEL

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

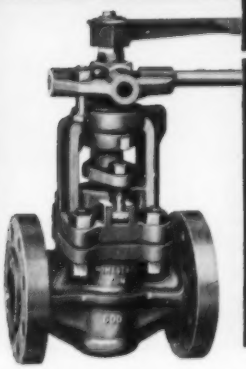
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Phillips Chemical	Phillips, Texas	Exp. Butadiene Cap.	90 tons		Under Constr.	July, 1957		Tellepsen; Phillips	
Premier Pet. Co.	**Longview, Tex.**	**Cat. Poly. Plt.**			**Under Constr.**				
The Pure Oil Co.	**Smith Bluffs, Texas**	**Cat. Reformer**	12,000 bbls.		Complete		Standard-Ind.	Parsons	Parsons
The Pure Oil Co.	Smith Bluffs, Tex.	Feed Preparation	20,000 bbls.		Completing		Standard, Ind.	Parsons	Parsons
Republic Refining	Texas City	Revamp Thermal Cracker	20,000 bbls.	$600,000	Completing		UOP	Treco	Treco
Rhom & Haas	Houston	Methanol	100 tons		Engineering	1st Qtr., 1957	Texaco	Foster Wheeler	Foster Wheeler
Shell Chemical	Norco, La.	Hydrogen Peroxide; Offsite Facl.			Under Constr.	March, 1957		Braun, Fluor	Braun, Fluor
Shell Oil	Houston	Cat. Reformer	16,000 bbls.		Complete			Procon	Procon
		Hydrodesulfurization Unit	16,000 bbls.		Complete				Procon
Shell Chemical	Houston	Bisphenol Expan.			Complete			Lummus	Lummus
Southwestern Oil & Refining	Corpus Christi, Texas	Platformer	9,000 bbls.	$2,195,000	Complete		UOP	Treco	Treco
Standard-Texas	El Paso	Ref. Exp.	†25,000 bbls.		Planning				
Stanolind Oil & Gas Co.	Ector County, Texas	Add Gas Comp.	52 Mmcf	$200,000	Complete			Staff	Dresser
Stanolind Oil & Gas.	Brownsville, Texas	Recondition & Revamp			Complete			Staff	Lummus
Sunray Mid-Continent	Sarapta, La.	Cycling Plt. Expan.	†7.5 Mmcf	$225,000	Complete			Staff	J. B. Gill
Sunray Mid-Continent	Ingleside, Texas	Nat. Gasol. Plt.	220 Mmcf	$3,000,000	Complete			Dresser	Dresser
Suntide Refining Co	Corpus Christi, Texas	Ref. Expan.	†10,000 bbls.		Completing				
Texas Asphalt & Ref.	Pasadena, Tex.	Asphalt Ref.	2,500 bbls.	$1,000,000	Complete			Ponca	Ponca
Texas City Refining	Texas City, Tex.	Cat. Reformer	6,000 bbls.		Planning				
Texas Butadiene & Chemical Corp.	Houston	Aviation Alkylate, Butylenes & Butadiene		$26,000,000	Under Constr.	Late 1956	Houdry, Phillips	Fluor	Fluor
*Texas Eastman	Longview, Texas	Inc. Polyethylene Cap.	†20,000,000 lbs./yr.		Planning				
Texas Eastman	Longview, Texas	Inc. Oxo Fac.			Planning	1956			
Texas Gulf Producing	Odessa, Texas	Exp. Gaso. Plt.	†35 Mmcf	$1,250,000	Under Constr.				Fish
U. S. Rubber	Baton Rouge, La.	Petrochemicals		$5,000,000	Under Constr.	July, 1957		Tellepsen	
ROCKY MOUNTAIN									
American Gilsonite	Fruita, Colo.	Gasoline from Gilsonite	7000 bbls.	$10,000,000	Under Constr.	Late 1956			Foster, Wheeler Kaiser Eng.
		Hydrogen	550 Mmcf		Engineering			Girdler	Ferguson
Atlantic Refining Co.	Lovington, N.M.	Natural Gas	25 Mmcf.		Projected				
Continental Oil	Artesia, N. M.	Reformer	1500 bbls.	$500,000	Complete		Houdry	Treco	Treco
*El Paso Natural Gas Products	Gallup, N.M.	Refinery: Alkylation, Cat. Reforming, Cat. Cracking, Vacuum, Crude Unit			Planning	Fall 1957	UOP		
First National Petroleum Corp.	Jensen, Utah	Ref. Expan.	To 3,000 bbls.		Planned				
*Sioux Oil Co.	Newcastle, Wyo.	LPG Unit		$60,000	Under Constr.	Aug., 1956		Litwin	Litwin
Sioux Oil	Newcastle, Wyo.	Cat. Reformer	750 bbls.	$225,000	Complete		Houdry	Litwin	Staff
Socony Mobil	Casper, Wyo.	Thermal Crkg.			Completing			Stearns-Rogers	Stearns-Rogers
Standard-Indiana	Mandan, N.D.	Ultraformer	5,400 bbls.		Under Constr.	Late 1956	Standard-Ind.	Parsons	Parsons
Standard-Indiana	Casper, Wyo.	Lube Oil Plt.	5,000 bbls.						
		Vacuum Pipe Still	4,800 bbls.						
		Propane Deasphalting	1,000 bbls.		Engineering	May, 1957		Foster Wheeler	Foster Wheeler
		Furfural Extraction	1,500 bbls.						
		MEK Dewaxing Deoiling	2,000 bbls.						
The Texas Co.	Casper, Wyo.	Cat. Reformer	4,800 bbls.		Complete		U.O.P.	Fluor, U.O.P.	Fluor
Union Oil Co. (Calif.)	Rifle, Colo.	Shale Demonstration Plt.	30 tons/day	$5,000,000	Under Constr.		Stearns-Rogers	Stearns-Rogers	Stearns-Rogers
Utah Oil Refining	Salt Lake City	Ultraformer	5,500 bbls.	$3,000,000	Complete		Standard-Ind.	Fluor	Fluor
Western States Refg.	Salt Lake City	Cat. Reformer	1,000 bbls.	$300,000	Under Constr.		Houdry		
WEST COAST									
Bankline Oil	Bakersfield, Calif.	Coking Plt.	4,000 bbls.	$2,000,000	Under Constr.	Sept., 1956	Esso	Fluor	Fluor
		Cat. Reformer	4,000 bbls.	$1,000,000				Fluor	Fluor
		Alkylation	1,500 bbls.		Complete			Fluor	Fluor
Brea-Koppers	Los Angeles	Ethylene			Planning				
		Polyethylene		$10,000,000	Under Constr.	Mid 1957	Koppers	Koppers	Koppers
California Stray Chemical	Richmond, Calif.	Fertilizer Plt.		$3,000,000	Under Constr.	Mid-1956			
Consolidated Mining & Smelting	Portland, Ore.	Urea Plt.	100 tons		Planning				
		Ammonia Plt.	200 tons		Planning				
Dow Chemical	Pittsburg, Calif.	Synthetic Latex		$1,000,000	Under Constr.	Fall 1956			
Du Pont	Antioch, Calif.	Fluorinated Hydrocarbons			Under Constr.	4th Qtr., 1956			
		Tetrethyl Lead							
Dupont	Antioch, Calif.	Sodium, Ethyl Chloride, Trichlorethyene, Perchorethylene			Complete				
Golden Bear Oil	Bakersfield, Cal.	Vacuum Unit	3500 bbls.	$100,000	Under Constr.			E&A	E&A
*Hancock Chemical	Wilmington, Calif.	Inc. Sulfur Recovery	†130 tons	$1,500,000	Under Constr.	Fall 1956		Parsons	Parsons
Hancock Oil Co.	Signal Hill Calif.	Fluid Coking Unit	6,000 bbls.	$1,814,800	ODM Certified			Parsons	Patsone
		Cat. Reformer	3,000 bbls.	$1,000,000	Complete		Standard (Ind.)	Parsons	Parsons
Kopper & Brea	West Coast	Polyethylene Plt.	50,000,000 lbs./yr.		Planning	1957			
Phillips Pacific	Kennewick, Wash.	Ammonia Plt.	200 tons	$12,000,000	Under Constr.			Fish	Fish
*Richfield Oil	Washington State	Refinery			Considering				
Richfield Oil	Watson, Calif.	Cat. Reformer	17,000 bbls.		Complete		Sinclair-Bakers	Parsons-Staff	Parsons
Richfield Oil	Wilmington, Calif.	Diethanolamine-Regeneration, Water-Reclaiming		$500,000	Engineering			Macco	Macco

Construction Boxscore Continued on Page 242



if your problem is...

- TEMPERATURE
- PRESSURE
- CORROSION...



HOMESTEAD *Lever-Seald* **PLUG VALVES** *will solve it...*

Conditions which cause ordinary valves to fail --corrosive, erosive, viscous, or volatile hard-to-hold fluids, plus temperature or pressure extremes --are everyday jobs for Homestead Lever-Seald Valves. Why? Because they *are built to operate under all conditions!* They never stick!

Every Homestead Lever-Seald Plug Valve has a powerful lever and screw device that does double duty. It presses the tapered plug firmly into its seat to form a drop-tight seal, and also provides a positive means to relieve seating pressure and permit easy operation.

Lever-Seald Homestead Valves give extra long, leak-proof service, too, because all operating parts and seating surfaces are protected from line fluids in both the open and closed positions. You can prove their economy to your own satisfaction, by making your next replacement a Homestead Lever-Seald.

Your choice can be made from valves cast of metals and alloys to specification in sizes from 1″ to 12″; for pressures from vacuum to 1500 pounds; temperatures from 40° below zero to 1100°F. Dry seat or pressure gun lubricated optional.

You'll find our VALVE REFERENCE BOOK No. 39-3 interesting and helpful. It's yours for the asking.

MAIL THE COUPON TODAY!

Without obligation, send me Valve Reference Book No. 39-3 describing Homestead Lever-Seald Plug Valves.

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Company _____

Address _____

City _____ State _____

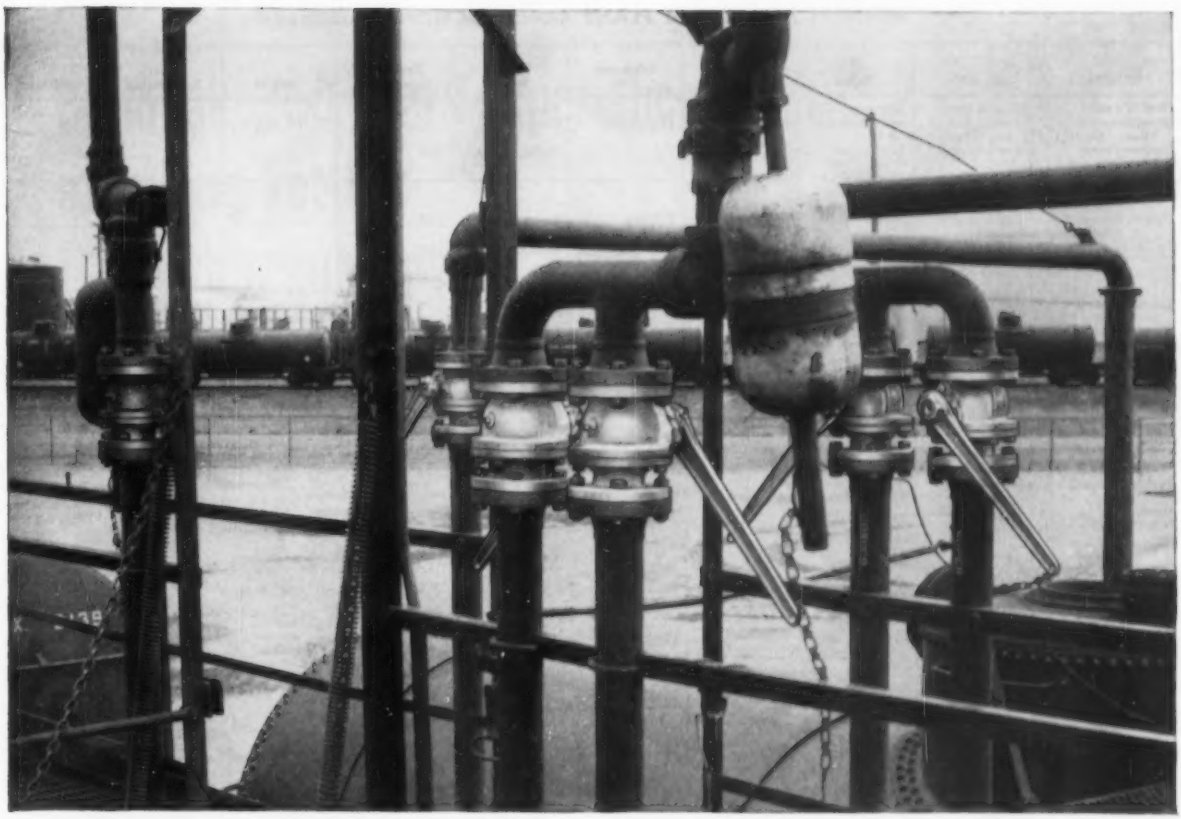
HOMESTEAD VALVE MANUFACTURING COMPANY

P. O. BOX 45 *"Serving Since 1892"* CORAOPOLIS, PA.

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Rothschild Oil	Santa Fe Springs, Calif.	Cat. Crker.	6,000 bbls.	$2,000,000	.....	.....	.....	.....	Braun
Shell Chemical	Ventura, Calif.	Urea Plt.	.....	.....	Under Constr.	Sept., 1956	Montecatini	Kellogg	Kellogg
Shell Chemical	Torrance, Calif.	Cold Latex	.....	.....	Under Constr.	Sept., 1956	.....	E&A	.....
Standard (Calif.)	Richmond, Calif.	Ammonia Plt.	300 tons	$12,800,000	Under Constr.	Mid-1956	Kellogg	Kellogg	Kellogg
Standard (Calif.)	Richmond, Calif.	Nitric Acid Plt.	225 tons			Mid-1956	.....	C. & I.	C&I (Macco)
Standard Oil (Calif.)	Honolulu	Refinery	30-30,000 bbls.	$25-30,000,000	Planned	Late 1957	.....	.....	.....
*Stauffer Chemical	Dominquenz, Calif.	Sulfuric-Acid Plt.	.....	$2,000,000	Under Constr.	Early 1957	.....	.....	.....
Stauffer Chemical	Compton, Calif.	Sulfuric Acid	.....	$57,070	Engineering	.....	.....	.....	.....
Stauffer Chemical	Richmond, Calif.	Sulfuric Acid	.....	$283,500	.....	.....	.....	.....	.....
Straits Refining	Puget Sound	Refinery	8,000 bbls.	$20,430,000	ODM Approved	.....	.....	Tears	Tears
Sunset Oil Co.	Portland, Ore.	Refinery	20,000 bbls.	.....	Considering	.....	.....	.....	.....
The Texas Co.	Anacortes, Wash.	Refinery	.....	.....	Planning	.....	.....	.....	.....
The Texas Co.	Wilmington, Cal.	Desaphalter	13,000 bbls.	.....	Complete	.....	.....	Texaco	Texaco
The Texas Co.	Wilmington, Calif.	Furfural Unit	25,000 bbls.	.....	Complete	.....	.....	Staff	Staff
Tide Water	Avon, Calif.	Fluid Coker	42,000 bbls.	.....			.....	Bechtel	Bechtel
		Hydrodesulfurizer	24,000 bbls.	.....	Under Constr.	3rd Qtr., 1956	.....	Bechtel	Bechtel
		Gas Plt.	.....	.....			.....	Betchel	Bechtel
		Exp. Fluid Cat. Cracking	.....	.....			.....	Bechetl	Bechtel
Union Oil (Calif.)	Santa Maria, Calif.	Sulfur Recovery	.....	.....	Complete	.....	.....	Bechtel	Bechtel
Union Oil (Calif.)	Edmonds, Wash	Two Asph. Stills	100 tons	$450,000	Complete	.....	.....	E&A	.....
U. S. Oil & Refining	Tacoma, Wash.	Refinery	15,000 bbls.	.....	Under Constr.	1957	UOP	J. B. Gill	J. B. Gill
*Wilshire Oil	Norwalk, Calif.	Unifiner-Platformer	10,000 bbls.	.....	Under Constr.	.....	UOP	Sweco	Sweco
OUTSIDE U.S.A.									
Canada									
Anglo-Canadian	Sarnia, Ont.	Ref. Exp.	25,000 bbls	.....	Under Constr	1956	.....	.....	.....
			30,000 bbls.	.....	Under Constr.	1957	.....	.....	.....
British American Oil	Clarkson, Ont.	Cat. Reforming	10,250 bbls.	$4,000,000	Under Constr.	Early 1957	Atlantic	Lummus	Lummus
British American	Clarkson, Ont.	Desulfurization	12,000	.....	Under Constr.	Early, 1957	.....	Lummus	Lummus
		Crude Exp.	40,000	$5,500,000	Under Constr.	Early, 1958	Atlantic	Kellogg	Kellogg
British American	Montreal	Desulfurization	15,550	.....	Engineering	Early, 1957	.....	Lummus	Lummus
		CO Boiler	.....	$650,000	Under Constr.	Early, 1957	Babcock-Wilcox	Babcock-Wilcox	Babcock-Wilcox
Canadian Gulf	Stettler, Atla.	Sulfur Recovery	225 tons	.....	Under Constr.	1957	.....	Parsons	Parsons
Canadian Hydrocarbons, Ltd.	Winnipeg, Manitoba	Fertilizer Plt.	600 tons	$18,500,000	Planning	.....	.....	.....	.....
Canadian Industries	Millhaven, Ont.	Anhydrous Ammonia Plt.	200 ton	$9,000,000	Under Constr.	Mid, 1956	Texaco	Girdler (Canada)	Girdler (Canada)
Canadian Oil	Sarnia, Ont.	Exp. Crude Unit, Cat Cracker	10,000 bbls.	$2,200,000	Completing	.....	.....	Staff	.....
*Canadian Oil	Sarnia	Udex Unit-Reformer	3,650 bbls.	$3,000,000	Planning	Aug., 1957	UOP	UOP, Staff	.....
			4,400 bbls.						
Canadian Petrofina	Montreal	Increase Cap.	.....	.....	Planning	.....	.....	.....	.....
Canada Southern Oils	Saskatchewan	Refinery	10-20,000 bbls.	$7,000,000-$10,000,000	.....	.....	.....	.....	.....
*Consumers Coop.	Regina	Refinery Expan.	†3,500 bbls.	$2,000,000	Planning	.....	.....	.....	.....
Dow Chemical	Sarnia, Ont.	Ethanolamine	.....	$1,000,000	Engineering	1956	.....	Catalytic	Catalytic
Du Pont	Maitland, Ont.	Orlon Plt.	.....	.....	Planning	.....	.....	.....	.....
Ethyl Corporation of Canada, Ltd.	Sarnia, Ont.	Anti-Knock Compound Plt.	.....	$14,000,000	Under Constr.	Mid 1956	.....	.....	.....
Goodrich, Canada	Niagara Falls	Polyvinyl Geon	.....	$3,500,000	Planning	Early 1957	.....	McKee	McKee
Imperial Oil	Imperoyal, N.S.	LPG Plt.	.....	$500,000	Completing	.....	.....	Foster Wheeler	Foster Wheeler
Imperial Oil	Imperoyal, N.S.	Hydroformer	7,000 bbls.	$4,300,000	Under Constr.	Dec., 1956	Esso	Foster Wheeler	Foster Wheeler
Imperial Oil	Sarnia	Detergent Alkylate	.....	$38,000,000	Planning	Mid 1957	.....	.....	.....
Imperial Oil	Redwater, Ala.	Gas Processing Plt.	10 Mmcf	$3,000,000	Under Constr.	Late 1956	Brown & Root	.....	.....
Imperial Oil	Sarnia	Expan. of Wax Facl.	35,000,000 lbs./yr.	$4,500,000	Under Constr.	Late, 1956	.....	Fluor, Imperial	Fluor
Imperial Oil	Sarnia	Steam Boiler	.....	$575,000	Complete	.....	.....	Babcock-Wilcox	Babcock-Wilcox
Imperial Oil	Sarnia, Ont.	Cat. Reformer	13,500 bbls.	$7,200,000	Under Constr.	Oct., 1956	.....	Fluor; Imperial	Fluor
*Imperial Oil	Halifax	FCC	15,000 bbls.						
		Cat. Poly	5,000 bbls.	.....	Under Constr.	Dec., 1956	.....	.....	.....
		Powerformer	7,000 bbls.						
Imperial Oil, Ltd	Halifax	Rebuild Existing Plt.	41,625 bbls.	.....	Complete	.....	.....	Foster Wheeler, Ltd.	Foster Wheeler Ltd.
Imperial Oil	Montreal	Cat. Reformer	9,000 bbls.	$5,100,000	Planning	Early 1957	.....	Fluor	Fluor
Imperial Oil	Ioco, B.C.	Powerformer Prefractionator Hydrofiner	5,000 bbls.	.....	Planning	Mid 1957	Esso	.....	.....
McColl-Frontenac	Edmonton, Alta.	Platformer	3,300 bbls.	$900,000	Engineering	Jan., 1957	UOP	Treco	Treco
Midland Pet. & Pacific Pet.	Stettler, Alta.	Crude Refinery	4,000 bbls.	$2,000,000	Under Constr.	.....	.....	.....	.....
North Star Oil	Grand Prairie, Alta.	Re-Locate Refinery	2500 bbls.	$4,500,000	Under Constr.	Aug., 1956	.....	Kellogg	Kellogg
Northwest-Nitro Chemical	Medicine Hat, Alta.	Phosphoric-Acid Plt.	.....	.....	Under Constr.	.....	.....	Fluor	Fluor
Northwest Nitro-Chemicals, Ltd.	Medicine Hat, Alberta	Nitrogen Plt.	.....	$23,000,000	Under Constr.	End, 1956	.....	Commercial Solvents	Ford, Bacon & Davis. Kellogg
*Pacific Petroleum	Fort St. John, B.C.	Gas-Absorption Plt.	.....	$18,000,000	Planning	.....	.....	.....	.....
Polymer Corp., Ltd.	Sarnia, Ont.	Ethylene Plt. Expan.	.....	$2,000,000	Under Constr.	1956	.....	Staff	Staff
Polymer Corp., Ltd.	Sarnia, Ont.	Plt. Expansion	.....	.....	Engineering	1956	.....	Catalytic	Canadian General Electric
Quebec Ammonia	Montreal	Ammonia Nitric Acid—80 tons Nitrogen Solutions	120 tons	$8,000,000	Engineering	2nd Qtr., 1957	Texaco	Girdler	Girdler
Regent Refining	Port Credit, Ont.	Fluid Cat Crker., Vacuum Distillation, Gas Polymerization	.....	$5,500,000	Planning	Jan., 1957	.....	Procon	Procon
Shawinigan Chemicals	Shawinigan Falls, Quebec	Sulfuric Acid	75 tons	$750,000	Under Constr.	Fall, 1956	.....	Chemico	Chemico
Shell Oil (Canada)	Montreal, East	Topping Expan.	11,000 bbls.	.....	Under Constr.	Mid, 1956	.....	.....	.....
		Platformer	6,000 bbls.	.....	Under Constr.	Mid, 1956	UOP	Procon	Procon
		Hydrodesulfuriser	7,500 bbls.	.....	Under Constr.	Mid, 1956	.....	.....	.....
		Offsite Facl.	.....	.....	Under Constr.	Mid, 1956	.....	Fluor	Fluor
*Shell Oil (Canada)	Alberta	Refinery	.....	.....	Studying	.....	.....	.....	.....

Construction Boxscore Continued on Page 244



He said leaking couldn't be stopped

...but Rockwood Ball Valves stopped it!

The resident engineer of a major oil company was skeptical when we told him about the exclusive features of Rockwood Ball Valves. It was impossible, he said, to keep racks free from messy oil conditions due to drippings from valves. But he agreed to replace his old style valves with Rockwood Valves.

He was surprised at the result — *absolutely no leaking from Rockwood Ball Valves.*

It's easy to see why Rockwood Ball Valves are leakproof when you examine them. You'll find—

Full Round Pipe Size Flow — no change in shape or volume of fluid stream — no turbulence — no minimum loss.

Quick Opening and Closing — only a quarter turn needed.

Longer wear resistance — Chrome-plated bronze ball withstands abrasion, pitting and scratching.

Leakproof Seal — pressure of fluid automatically positions ball against seat to form tight seal.

It works as good as it reads! Send coupon today for complete information. Rockwood Ball Valves come in all pipe sizes. Tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal industrial areas.

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1282 Harlow Street
Worcester 5, Mass.

Send me illustrated folder V-4 on Rockwood Full-Flow Ball Valves.

Name.....

Title.....

Company.....

City.....Zone....State.....

For more data on advertised products, use Readers' Service Cards, last page.

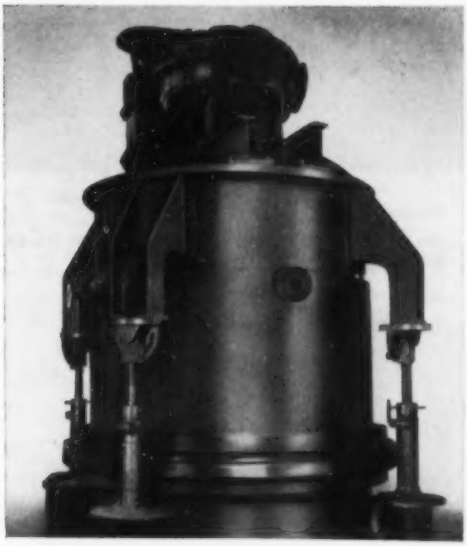
REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Shell (Canada)	Bronte, Ont.	Refinery	.....	.....	Considering	.....	.....	.....	.....
Sherritt-Gordon Mines, Ltd.	Fort Saskatchewan, Alta.	Anhydrous Ammonia	75 tons	$24,000,000	Planned	.....	.....	.....	.....
Surpass Petro-Chemicals	Scarborough, Ont.	Sulphonates	.....	.....	Under Constr.	1956	.....	.....	.....
LATIN AMERICA									
Argentina									
Fabrica Argentina	San Nicholas	Phenol Plt.	.....	$375,000	Under Constr.	Fall, 1956	.....	.....	.....
Brazil									
*Alba	Cubatao	Methanol, Formaldehyde, Synthetic Resins	.....	$3,500,000	Engineering	1958	.....	.....	.....
Cia Brasiliera de Estireno	Cubatao	Styrene Monomer Plt.	.....	.....	Under Constr.	Late 1956	Koppers, Firestone	Koppers	Koppers
*Copebras	Cubatao	Carbon-Black	18,000 tons/yr.	.....	Engineering	.....	.....	.....	.....
Petrobras	Cubatao	Anhydrous Ammonia	100 tons	$6,000,000	Under Constr.	Late 1956	Texaco Dev., Ammonia Casale	Foster Wheeler	Foster Wheeler Staff
		Nitric Acid	345 tons						
		Ammonium Nitrate	35 tons	$11,000,000	Under Constr.	Aug., 1956	.....	†Friedrich Uhde	Uhde, Staff,
		Fertilizer	340 tons					Uhde	Uhde, Staff
Petrobras	Cubatao	Ethylene Recov.	45,000,000 lb./yr.	$1,800,000	Engineering	Late 1956	.....	Kellogg	Kellogg, Staff
*Petrobras	Mataripe	Inc. Capacity	†32,000 bbls.	.....	Planning	.....	.....	Hydrocarbon, Hydro. M.	Staff
Petrobras	North Brazil	Refinery	25,000 bbls.	.....	Studying	.....	Kellogg	Kellogg	.....
Petrobras	South Brazil	Refinery	70,000 bbls.	.....	Studying	.....	.....	.....	.....
*Uhde	Cubatao	Urea Pet.	.....	.....	.....	.....	.....	.....	.....
*Union Carbide	Cubatao	Styrene Monomer	.....	.....	Engineering	.....	.....	Uhde	Uhde
Colombia									
Colombian Petroleum Company	Barco Concession	Gas Treating Plt.	2,000 bbls.	$5,000,000	Under Constr.	.....	.....	.....	.....
*Empresas Nacional Petroleos	Barranca Bermeja	Exp. Propane Recovery Petrochemicals	.....	.....	Planning	.....	.....	.....	.....
International Petroleum (Colombia), Ltd.	Cartagena	Refinery	26,500 bbls.	$32,500,000	Considering Under Constr.	3rd Qtr., 1957	Esso	Bechtel	Bechtel
Cuba									
*Esso Standard	Havana	Ref. Expan.: Distillation, Polymerization, Powerforming, Hydroforming, Cat. Cracking	To 35,000 bbls.	$30,000,000	Under Constr.	Late 1957	Esso	McKee	McKee
Refinadora Cabaiguan	Cabaigun, Cuba	Ref. Expan.	.....	.....	Planning	.....	.....	.....	.....
Shell de Cuba	Havana	Refinery	25,000 bbls.	.....	Under Constr.	Nov., 1956	.....	Bechtel	Bechtel
The Texas Co.	Santiago	Refinery	20,000 bbls.	$14,000,000	Under Constr.	Early, 1957	.....	.....	.....
Mexico									
Pemex	Mexico City	Cat. Cracking	16,000 bbls.	$12,500,000	Under Constr.	Mid 1957	Esso-Phillips U.O.P.	McKee	Staff
		Gas Concentration, HF Alkylation; Polymerization; Ethylene; Sulfure							
Pemex	Pemex City	Nat. Gaso. Plt.	300 Mmcf	$7,400,000	Under Constr.	Early, 1957	.....	Hudson	Staff
Pemex	Ciudad Madero	Topping	100,000 bbls.						
		Cat. Cracking	16,000 bbls.						
		Gas Concentration; HF Alkylation; Polymerization; Sulfure Plt.		$25,700,000	Under Constr.	Late 1957	Phillips	McKee	Staff
Pemex	Minatitlan	Vacuum Distillation; Clay Treating; Lube Oil	1,000 bbls.	$2,500,000	Under Constr.	Late 1956	.....	Fluor	Staff
Pemex	Salamanca	Grease Plt.	25 tons	$1,700,000	Engineering	Early, 1957	.....	McKee	Staff
Pemex	Poza Rica	Cat. Cracker	15,000 bbls.	.....	Planning	.....	.....	.....	.....
		Topping Plt.	10,000 bbls.	$1,350,000	Engineering	Late 1956	.....	Staff	Staff
Netherlands Antilles									
Lago O&T	Aruba	Expand Distillates Upgrading Fac.	†20,000 bbls.	$4,200,000	Under Constr.	Dec., 1956	.....	Badger Mfg.	Badger Mfg.
N. V. Curacaosche Petro. Ind. Mij.	Curacao	Feed Prep.	20,000 bbls.	.....	.....	Mid 1957	.....	.....	.....
			33,000 bbls.	.....	Planned	End, 1957	.....	S & W. Badger Div., E. B. Badger, Ltd.	.....
Panama									
*Refineria Petroquimica de Panama	Colon	Refinery	55,000 bbls.	.....	Planning	.....	.....	.....	.....
*Refineria Panama	Colon	Refinery	70,000 bbls.	.....	Planning	.....	.....	.....	.....
Peru									
Fertisa Limitada	Peru	Fertilizer Plt.	.....	.....	Planning	1956	.....	Montecatini	.....
Helios, S.A.	San Andreo	Fertilizer Plt.	130,000 tons	.....	Planning	.....	.....	.....	.....
Helios, S.A.	San Andreo	Lube Oil; Asphalt Refinery	60,000 tons lube oil; 10,000 tons Asphalt/yr.	$8,000,000	Complete	.....	.....	Hydrocarbon	.....
Puerto Rico									
Gonsalez Chemical	Guanica	Ammonia	125 tons	$12,250,000	Under Constr.	Late 1956	Texaco	Lummus	Lummus
Venezuela									
Mene Grande-Creole	San Joaquin	Gasoline Plt.	.....	$2,300,000	Planning	.....	.....	.....	.....
Cia Shell de Venezuela	Cardon	Cat. Crker.	33,000 bbls.	.....	Under Constr.	Oct., 1957	.....	.....	.....
Cia Shell de Venezuela	Cardon	Polymerization; Treater, Feed Preparation	.....	.....	Under Constr.	.....	.....	H.W.P.	.....
Cia Shell de Venezuela	Cardon	Feed Prep.	66,000 bbls.	.....	.....	1956	.....	S & W Badger Div., E. B. Badger, Ltd.	.....
*Shell (Venezuela)	Cardon	Distillation	80,000 bbls.	$20,000,000	Planning	.....	.....	.....	.....
		Alkylation	1,400 bbls.	.....	Projected	2nd Qtr., 1957	.....	.....	.....
Creole Pet. Corp.	Amuay Bay	Pipe Still	70,000 bbls.	$10,800,000	Under Constr.	.....	.....	.....	.....
Richmond Exploration	Maracaibo	Asphalt Plt.	10,000 bbls.	$4,000,000	Under Constr.	.....	.....	Foster Wheeler	Foster Wheeler
Venezuela Gulf	Puerto La Cruz	Visbreaker	14,000 bbls.	.....	Complete	.....	.....	.....	.....
Venezuela Gulf	Puerto La Cruz	Fluid Catalytic Cracking	8,000 bbls.	.....	Under Constr.	Late 1956	Kellogg	Gulf Kellogg	Vengref Kellogg

Construction Boxscohe Continued on Page 246

Buflovak...50 years experience matching kettles with requirements

500-gallon one-piece cast jacketed Pressure Saponifier with Double Motion Agitator.



1500-gallon Dowtherm heated, jacketed Kettle with Double Motion Agitator and Thermocouple.

3000-gallon steam jacketed, fabricated steel Grease Mixing Kettle.

To a great extent, processing profits depend upon the quality and efficiency of the processing equipment. Proper equipment design is in turn determined by such factors as end product, quantities to be handled, method of heating and cooling, agitators and drive to be employed, heat source, and high or low temperature control.

Blaw-Knox engineers have the years of practical experience and technical know-how necessary to combine all these factors into equipment that will best meet *your* processing needs. We can build kettles to your design; or, engineer, design and construct kettles to meet your requirements. Either way, Buflovak Kettles are your assurance of highest processing profits. Write or call us today about *your* processing problem.

a broad process equipment service

Kettles of every description constitute but one phase of Blaw-Knox Process Equipment design, engineering and fabrication service for the chemical, food, pharmaceutical, plastic and resin, petroleum, rubber and other industries:

EVAPORATION • DRYING • FLAKING
MIXING • IMPREGNATING • REACTION
VULCANIZING • SOLVENT RECOVERY
SOLVENT EXTRACTION • STERILIZING
CRYSTALLIZATION • DISTILLATION
POLYMERIZATION • GAS CLEANING
GAS ABSORPTION • VAPORIZATION
CONDENSATION • HEAT TRANSFER
LOW AND HIGH PRESSURE PROCESSING

Write for Bulletin 356-R for more information on Buflovak Processing Kettles for heating, cooling, mixing, drying, concentrating, crystallizing and reactions.

50th Anniversary BLAW-KNOX 1906 1956

BLAW-KNOX COMPANY
Buflovak Equipment Division
1601 Fillmore Avenue, Buffalo 11, New York

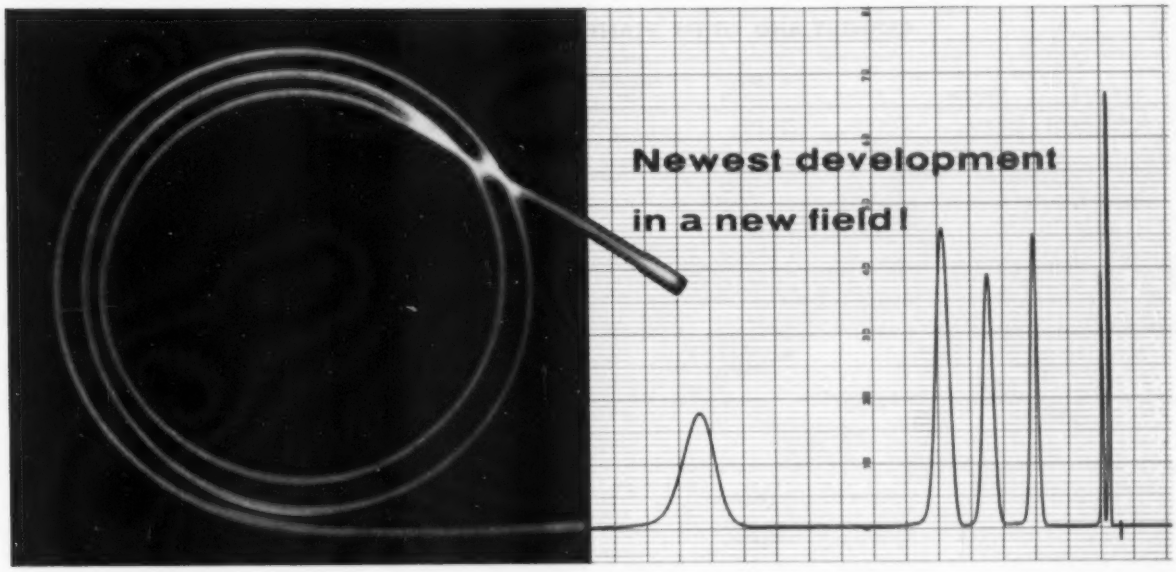
Makers of process equipment engineered for any pressure, temperature, capacity or reaction

For more data on advertised products, use Readers' Service Cards, last page.

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EUROPE AND AFRICA									
Belgium									
Esso	Antwerp	Exp. Ref.			Under Constr.				
Petrochim	Antwerp	Ethylene Oxide, Ethylene Glycol		$8,000,000	Engineering	SD	SD	SD	
Raf Belge de Petroles	Antwerp	Cat. Reformer			Engineering		Sinclair-Baker	KIC	KIC
		Desulfurization			Engineering		Sinclair-Baker	KIC	KIC
Denmark									
A. P. Moeller	Copenhagen	Refinery		$11,500,000	Planning				
Egypt									
Egyptian Government	Cairo	Topping	40,000 bbls.	$3,000,000	Under Constr.	Sept., 1956			
England									
Berry Wiggins & Co., Ltd.	Waste Ref., Manchester.	Extension to Refinery	500 bbls.		Under Constr.			H.W.P.	H.W.P.
South Eastern Gas Board	Isle of Grain	Oil Gasification	15 Mmcf		Under Constr.	Fall, 1958		Power Gas	Power Gas
British Petroleum	Kent	Hydrofiner	8000 bbls.					KIC, S&W	KIC, S&W
British Petroleum	Kent	Alkylation Plt.	2,600 bbls.					Badger, E.B.	Badger, E.B.
British Petroleum	Kent	Distillation Unit	190,000 bbls.	$73,000,000	Under Constr.	Late 1957		Badger, Ltd.	Badger, Ltd.
		Platforming	10,000 bbls.						
		Thermal Reforming	10,000 bbls.						
*British Petroleum	Kent	Armonatic Recovery; Iso Pentane Fractionation; Depropanizer; Iso Pentane Washer			Engineering			S&W Badger Div., E. B. Badger, Ltd.	
Esso Petroleum Co.	Fawley	Refinery Expan.	†35,000 bbls.	$14,300,000	Under Constr.				
		Hydroforming	15,000 bbls.		Complete			Esso	Foster Wheeler
		Hydrofining	12,000 bbls.		Under Constr.				
Hedon Chemicals	Hedon, Yorks.	Vinyl Acetate			Under Constr.				
Imperial Chemicals	Billingsham	Ammonia Plt.	200 tons		Planning		Texaco	Imperial	Imperial
Imperial Chemical Industries	Billingsham	Alcohols	†40,000 tons/yr.		Engineering	End, 1956		Staff	
Imperial Chemical Industries	Wilton	Chemical Plt.	20 tons			1956		S & W Badger Div.	E. B. Badger & Sons, Ltd.
Imperial Chemical Industries	Wilton	Butadiene Separation Plt.	6/7000 ton/yr.		Design			H.W.P.	
Imperial Chemical Industries	Wilton	Extension of Cracker	†250,000 tons/yr.		Under Constr.	3rd Qtr., 1956		Staff and Kellogg	KIC
*International Synthetic Rubber	Southhampton	Synthetic Rubber	50,000 ton/yr.		Planning	1957			
Mobil Oil Company	Coryton	Sovaformer	6,000 bbls.		Completing			Bechtel	Bechtel
Monsanto Chemicals	Britain	Add Polystyrene			Under Constr.			Staff	Staff
Monsanto Chemicals	Britain	Styrene-Butadienne Copolymer Plt.	4,000 tons/yr.	$14,000,000	Planned				
*Petrochemicals	Partington	Inc. Ethylene Oxide, Glycol Ether Polyglycols	To 25,000 tons/yr.		Under Constr.	Dec., 1956	Esso	CTIP	
Philblack	Avonmouth	Carbon Black Plt.	85 tons		Under Constr.	1956		E.B.Badger, Ltd.	E.B.Badger, Ltd.
*Regent Oil	Southern England	Refinery			Planning	1958			
Shell Chemical	Shell Haven	Ammonia; Nitric Acid	75,000 tons/yr.	$18,500,000	Planning	1958			
		Fertilizer		$12,500,000	Planning				
*Shell Refining and Market, Inc.	Shell Haven	Atmospheric Distillation	80,000 bbls.		Engineering	Mid 1958		S&W Badger Div., E. B. Badger, Ltd.	E. B. Badger, Ltd.
Finland									
Neste Oy Corp.	Turku, Finland	Refinery	14,000 bbls.	$17,500,000	Planning		Atlantic, Soc. Mob., Calif. Res.		
France									
Antar Petroles de l'Atlantic	Donges	Cat. Reformer	10,800 bbls.		Engineering		Houdry, U.O.P.	Hydrocarbon, Hydro M.	Staff
*Cabot of France	Berre Lake	Carbon-Black Plt.			Planning	1957			
Comp. de Raffinage Shell Berre	Petit Couronne	Cat. Crker.	12,000 bbls.		Under Constr.	Mid 1956			
		Feed Prep.	28,000 bbls.			1956		S & W Badger Div. E. B. Badger, Ltd.	
Comp. Francaise de Raffinage	Gonfreville	Refinery Expan.			Under Constr.	Mid, 1956		Kellogg	KIC
Comp Francaise de Raffinage	Provence	Desulfurization						KIC	KIC
*Esso Standard	Girdonde-Bordeaux	Refinery			Planning				
Esso Standard	Port Jerome	Cat. Cracker	10,000 bbls.	$11,000,000	Planning	Early 1957			
Francolor	France	Maleic-Anhydride			Engineering		SDC		
Naphtachimie	Lavera	Exp. Ethylene Oxide			Under Constr.	1957	SDC	S&W Badger Div.	
Pechiney	St. Auban	Perchlorethylene Plt.			Planning		SDC	SDC	
Potasse et Engrais Chimiques	Grand Couronne	Ammonia					SBA	KIC	KIC
Societe du Caoutchouc Butyl	Le Havre	Synthetic Rubber Plt.	20,000 tons/yr.		Engineering	Mid 1958	ESSO		
Caltex S.D.F.	Ambes	Cat. Crker.	4,600 bbls.		Under Constr.	1957			Lummus
		Vacuum Unit	6,300 bbls.		Under Constr.	1957		Lummus	Lummus
		Poly Plt.	540 bbls. (Product)		Under Constr.	1957	C.R.C.	Foster Wheeler	Lummus
Societe Francaise des Petroles BP	Dunkirk	Bitumen Plt.	500-700 tons		Under Constr.	1956			
*Soc. Francaise des Petroles BP	Dunkirk	Cat. Reformer			Planning	Late 1957			
*Soc. Francaise des Petroles BP	Lavera	Distillation	To 60,000 bbls.		Under Constr.	Late 1957			
*Soc. Nationale des Petroles D'Aquitaine	Lacq	Sulfur Recovery			Planning			Parsons	Parsons
*Soc. Rhone-Poulence	Gonfreville	Polyethylene			Licensed		Phillips		
Societe Rhone-Poulence	France	Polyethylene			Engineering		SDC		
West Germany									
*Badische Aniline und Soda Fabrik	Ludurighafen	Polyethylene			Licensed		Phillips		

Construction Boxscore Continued on Page 248



Beckman / *gas chromatograph*

...precision, low-cost instrument for analyzing gases and low-boiling liquids

Gas chromatography is perhaps the most significant analytical development in the past 20 years. Now, Beckman advances this new technology still further with a compact, inexpensive Gas Chromatograph, designed specifically to analyze gases and mixtures of liquids that boil below 80°C.

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- Wherever gases and low-boiling liquids require accurate, fast analysis ...

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For more data on advertised products, use Readers' Service Cards, last page.

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Benzin und Petroleum	Hamburg	Hydrofiner	5250 bbls.	.....	Planning	1956	.....	.....	.....
Chemische Werke Huels, A.G.	West Germany	Synthetic Rubber Plt.	30,000 t/y	$24,000,000	Considering	.....	Esso R&E; Houdry	Cat. Constr.	.....
*Deutsche Vacuum Oil	Bremen-Osleb-shausen	Sovaformer	3,200 bbls.	.....	.....	.....	.....	.....	.....
		Sovafiner	4,800 bbls.	.....	Under Constr.	1957	Socony Mobil	.....	.....
		Sulfur Plt. Distillation							
Esso	Cologne	Refinery	60,000 bbls.	.....	Planning	1959	.....	.....	.....
Etablissements Kuhlmann	.....	Ammonia Plt.	60 tons	.....	.....	.....	Texaco	Kuhlmann	Kuhlmann
Kohle-Oil Chemie	Gelsenkirchen	Polyethylene	24,000 ton/yr.	.....	Planning	.....	.....	.....	.....
Ruhrbau	Mulheim	Refinery	15,000 bbls.	.....	Planning	.....	.....	.....	.....
Socony Mobil	Bremen	Hydrodesulfurization	5,500 bbls.	.....	.....	.....	.....	Braun	Braun
Greece									
Greek Government	Piraeus	Refinery	30,000 bbls.	$15,000,000	Under Constr.	Jan., 1957	Atlantic	Hydrocarbon	Hydro. M, Krupp, Stahlunion, Stahlbau
Ireland									
Eire Government	Whitegate	Refinery	.....	.....	Negotiating	.....	.....	.....	.....
Esso Petr. (Ireland)									
Caltex (Ireland)									
Irish Shell									
Italy									
Ente Nazionale Idrocarburi	Ravenna	Butadiene Plt.	30,000 tons a yr. Rubber	75,000,000	Under Constr.	1957	.....	Union Carbide Carbon;	Brown-Root
		Copolymer Plt.	350,000 tons a year		Under Constr.	1957	.....	Phillips Petroleum	Brown-Root
		Ammonia; Fertilizers	.....	.....	.....	1957	.....	.....	.....
Golfo Industria Petrolifera S.P.A.	Gaeta, Italy	New Refinery	15,000 bbls.	.....	.....	.....	.....	Tecnider	.....
*Industria Petrolifera (STANIO)	Bari	Ultraformer	5,000 bbls.	$2,000,000	Under Constr.	Dec., 1956	Esso	CTIP	.....
*Raffineria Dott. E. Garrone	Genova	Ultraformer	5,000 bbls.	$2,000,000	Under Constr.	Dec., 1956	Esso	CTIP	.....
*Raffineria Siciliana Oli Minerali (RASIOM)	Augusta	Ultraformer	5,000 bbls.	$2,000,000	Under Constr.	Dec., 1956	Esso	CTIP	.....
*Soc. Solvay & Cie	Italy	Polyethylene	.....	.....	Licensed	.....	Phillips	.....	.....
*Turkish-American Oil	Istanbul	Refinery; Crude-Vacuum; Cat Cracker, Vapor Recovery, Cat Poly, Treating	15,000 bbls.	$12,000,000	Approved	Aug., 1958	.....	.....	.....
Purifina Italiana	Milan	Distillation Unit	15,000 bbls.	.....	Planning	.....	.....	.....	.....
Shell Italiana	Palermo	Refinery	20,000 bbls.	.....	Planning	.....	.....	.....	.....
SAROM	Ravenna	Iso-Plus Houdriformer	4000 bbls.	.....	Complete	.....	Houdry	Houdry; Lummus	Breda
Netherlands									
Caltex Petroleum	Pernis	Platformer	7,000 bbls.	.....	Under Constr.	1957	U.O.P.	Lummus, Ltd.	Lummus-Werkspoor
		Desulfurization	4,000 bbls.	.....	Under Constr.	1957	U.O.P., Union	Lummus, Ltd., Parsons	Lummus-Werkspoor
Mekog	Velsen-Ymuiden	Nitrigen Fertilizer	.....	$9,000,000	Planning	.....	.....	.....	.....
Nederlandsche Dow Maatschappij N.V.	Rotterdam	Processing Plt.	.....	.....	Planned	.....	.....	.....	.....
N. V. de Bataafsche Pet. Maatschappij	Pernis	Syn. Glycerine	.....	$7,000,000	Under Constr.	Late 1957	.....	.....	.....
N. V. de Bataafsche Pet. Maatschappij	Pernis	Vacuum Still	66,000 bbls.	.....	Engineering	.....	.....	S&W Badger Div., E. B. Badger, Ltd.	.....
		Cat. Crker.	33,000 bbls.	.....	Under Constr.	3rd Qtr., 1956	.....	.....	.....
Norway									
Standard (N.J.)	Oslo Fjord	Refinery	.....	.....	Negotiating	.....	.....	.....	.....
Portuguese W. Africa									
Petrofina	Luanda	Refinery	.....	.....	Planning	.....	.....	.....	.....
Scotland									
British Hydrocarbon Chemicals	Grangemouth	Additional Cracking	.....	.....	Planning	.....	.....	S&W Badger Div.	E. B. Badger, Ltd.
		Gas-Separating	.....	.....	Planning	.....	.....	S&W Badger Div.	E. B. Badger, Ltd.
		Ethanol, Ethylene, Tetrapropylene		$13,000,000	Planning	1956	Shell Chem. UOP	S&W Badger Div.	E. B. Badger, Ltd.
		Butadiene	.....	.....	Planning	.....	.....	KIC	KIC
Spain									
Refineria de Petroleos de Escombreras S.A.	Escombreas	Refinery Expan.	160,000 bbls.	.....	Under Constr.	1957	.....	.....	Foster Wheeler
		Platformer	8,000 bbls.	.....	Under Constr.	1957	UOP	U.O.P., Foster Wheeler	Foster Wheeler
Sweden									
Johnson Line	Gothenburg	Refinery	2,500 bbls.	.....	Planned	.....	.....	Staff	Staff
Trieste									
S.P.A. Tecnico Industriale Aquila	Trieste	Cat. Cracking	3,300 bbls.	.....	Under Constr.	.....	Soc.-Vac.	Staff	Staff
		Cat. Poly.	1,400 bbls.	.....	Under Constr.	.....	U.O.P.	Staff	Staff
Turkey									
Badische Anilin and Soda Fabrik	Kutefia	Ammonium Sulfate	60,000 tons/yr.	$20,000,000	Planning	1958	.....	.....	.....
		Sulfuric, Nitric Acid	50,000 ton/yr.						
Turkish Governm't	Istanbul	Nat. Gaso. Plt.	.....	.....	Planning	.....	.....	.....	.....
Union of South Africa									
Union Petrol Refinery, Ltd.	Johannesburg	Refinery	.....	$20,000,000	Projected	.....	.....	.....	.....
NEAR EAST									
Aden									
*British Petroleum	Aden	Thermal Reformer	8,000 bbls.	.....	Under Constr.	.....	.....	.....	.....
Bahrain									
Bahrain Petroleum	Bahrain	Platformer	10,000 bbls.	.....	Engineering	1957	.....	Foster Wheeler	Foster Wheeler
Iraq									
Iraq Government	Iraq	Lube Oil Plt.	25,000 ton/yr.	.....	Planning	.....	.....	Foster-Wheeler	Foster-Wheeler
Jordan									
Jordanian Reconstruction Council	Mafrak	Refinery	.....	$7,500,000	Planned	.....	.....	.....	.....
Kuwait									
Kuwait Oil	Mina Al Ahmadi	Two Distillation Units	80,000 bbls. each	.....	Under Constr.	1957	.....	S&W Badger Div., E. B. Badger; Bechtel	Bechtel

Construction Boxscore Continued on Page 250

CONOCO

STANDARD

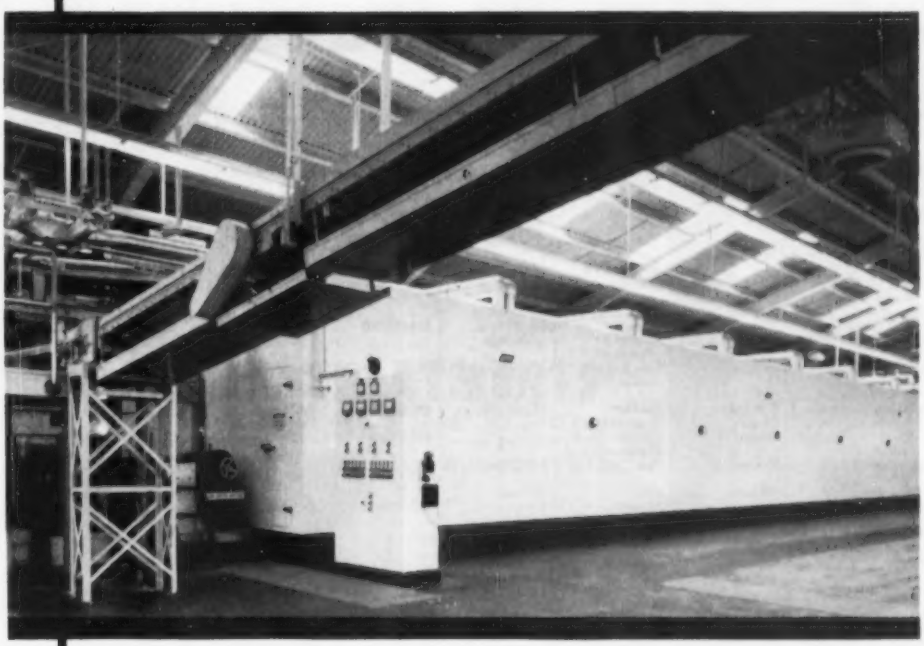
SINCLAIR OILS

Esso

GULF

STANDARD

CITIES SERVICE



New profits from Wax

MORE AND MORE refiners are slabbing wax faster, more economically with GREER Wax Moulders because Greer Moulding plants save labor and space . . . boost production . . . improve quality control.

ONE-MAN OPERATION . . . deposits, cools and demoulds cakes completely automatically. Virtually eliminates 85% of wax slabbing labor costs.

SAVES VALUABLE FLOOR SPACE . . . Packs your entire slabbing operation into floor space only 10 to 25% of that required by batch processes of equal capacity.

EXACT, DEPENDABLE WEIGHT CONTROL . . . Now you can mould cakes within ½ of 1% of desired weight — continuously, automatically. Automatic moulding means improved appearance and cleanliness of cakes, too.

NEW CHOICE OF SIZES . . . Ten-pound Slab Machine now available in two models from 2500-7500 pounds/hour, and 10,000-15,000 pounds hour.

WRITE for informative 9-page Bulletin 51-2

J. W. GREER COMPANY

WILMINGTON, MASSACHUSETTS

Sales Engineering Offices: Chicago, Ill., San Francisco, Calif.

GREER

For more data on advertised products, use Readers' Service Cards, last page.

REFINERY AND OTHER PLANT CONSTRUCTION—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Saudi Arabia									
Arabian American	**Ras Tanura**	**Asphalt Plt.**	**1,250 bbls.**	.....	**Planning**	**1956**	.....	.....	.....
Arabian American Oil Co.	**Ras Tanura**	**Hydrofiner**	**15,000 bbls.**	**$4,100,000**	**Under Constr.**	**Spring, 1957**	**Esso**	**Lummus**	**Lummus**
Saudi Arabian Government	**Saudi Arabia**	**Ammonium Sulfate Plt.**	**400,000 Metric tons/yr. Plus 500 Tons Dry Ice**	.....	**Proposed**	.....	.....	.....	.....
Syria									
*Esso Standard	Syria	Refinery	10,000 bbls.	.....	Proposed	.....	.....	.....	.....
Syrian Government	Homs	Refinery	12,000 bbls.	$3,000,000	Considering	.....	.....	.....	.....
FAR EAST									
Burma									
Burmah Oil	Syriam	Refinery	.....	.....	Under Constr.	.....	.....	.....	.....
Burmah Oil	Chauk	Auxiliary Fac.	.....	.....	Under Constr.	.....	.....	.....	.....
Ceylon									
Shell of Ceylon	**Hendola**	**Refinery**	.....	**$40,000,000**	Planning	.....	.....	.....	.....
India									
Assam Oil	Assam	Refinery	.....	.....	Considering	.....	.....	.....	.....
Burmah-Shell	Bombay	Cat. Reformer	6,700 bbls.	.....	Projected	3rd Qtr., 1956	.....	.....	.....
		Edeleanu Plt.	7,000 bbls.	.....	Projected	3rd Qtr., 1956	Edeleanu	.....	.....
Caltex Oil Refining (India) Ltd.	**Visakhapatnam**	**Refinery**	**12,500 bbls.**	.....	**Under Constr.**	**Early 1957**	.....	**Lummus Foster Wheeler**	**Lummus, CB&I**
Dow et al	Bombay	Polystyrene Plt.	2,700 ton/yr.	.....	Engineering	.....	.....	Bechtel	Bechtel
Indian Gov't	Bhavnagar	Refinery	30,000 bbls.	$42,000,000	Considering	.....	.....	.....	.....
Indian Government	**India**	**Synthetic Petroleum Plt.**	**6,000 bbls.**	.....	**Planning**	.....	.....	.....	.....
Standard Vacuum	**Bombay**	**Cat. Polymerization**	**350 bbls.**	.....	**Under Constr.**	**1956**	**Calif. Res.**	**Hydrocarbon**	**Foster Wheeler**
Japan									
Idemitsu Kosan Co.	**Tokuyama**	**Refinery**	**18,000 bbls.**	**$16,000,000**	**Under Constr.**	.....	**U.O.P.**	.....	.....
*Maruzen Oil Co.	Japan	Petrochemicals	.....	.....	Unconfirmed	.....	.....	.....	.....
*Mitsui Petrochemical Industries	Iwakuni City	Ehtylene Oxide Ehtylene Glycol	.....	$30,000,000	Under Constr.	Nov., 1957	SDC	S&W Badger Div.	.....
Mitsubishi Oil Co., Ltd.	**Tokyo**	**Vac. Distl. Unit**	**2,000 bbls.**	.....	.....	.....	.....	.....	.....
Nihon Gas Kagaku Kogyo	Niigata	Urea	905 tons		.....	Spring, 1957	.....	Chemico	Chemico
		Ammonia	100 tons	$2,100,000	Engineering	Spring, 1957	.....	Chemico	Chemico
		Ammonia Sulfate	200 tons			Late 1957	.....	Chemico	Chemico
Nippon Petroleum Refining	Yokohama	Topping Unit	20,000 bbls.	.....	Under Constr.	1956	.....	Staff	.....
Nippon Petroleum Refining	Kudamatsu	Crude Unit	15,000 bbls.	.....	Under Constr.	1956	.....	Staff	.....
Nippon Petrochemicals	.....	Isopropyl Alcohol; Acetone	.....	.....	Engineering	1957	.....	S&W Badger, Div.	.....
Showa Oil Company	**Tokuyama**	**Refining Fac.**	**30,000 bbls.**	**$39,000,000**	**Planning**	**June, 1957**	.....	.....	.....
Showa Oil Company	**Tokuyama**	**Petrochemicals**	.....	.....	Planning	.....	.....	.....	.....
*Sunitomo Chemical	Japan	Ethylene Unit	.....	.....	Engineering	1957	.....	S&W Badger Div.	.....
Korea									
Korean Government	**Chung-ju**	**Urea Plt.**	**185 tons**	**$25,000,000**	**Under Constr.**	.....	**Vulcan, Inventa, Texaco, Hydrocarbon**	**Hydrocarbon**	**Hydrocarbon**
Sumatra									
Standard-Vacuum	**Palembang**	**Cat. Cracker**	**11,000 bbls.**		.....	.....	.....	**Foster-Wheeler**	**Foster-Wheeler**
		Polymerization	**1,200 bbls.**	**$20,000,000**	**Planning**	.....	.....	**Foster-Wheeler**	**Foster-Wheeler**
		Revamp Existing Plt.	.....		.....	.....	.....	**Foster-Wheeler**	**Foster-Wheeler**
Formosa									
Chinese Petroleum Corp.	**Kaohsiung**	**Thermofor Cat. Crker.**	**10,000 bbls.**	.....	**Complete**	.....	**Soc.-Vac.**	**Fluor**	**Fluor**
Taiwan Fertiliser, Ltd.	**Nankong**	**Ammonia Plt. to Produce Urea**	**260 tons**	**$18,000,000**	**Under Constr.**	**Spring, 1957**	**Vulcan, Inventa**	**Hydrocarbon**	**Staff**
AUSTRALASIA									
Australia									
Bitumen & Oil Refineries	Sydney	Crude Unit	9,000 bbls.	.....	Under Constr.	1956	.....	.....	.....
Bitumen & Oil Refineries	Queensland	Crude Unit	5,000 bbls.	.....	Under Constr.	1957	.....	.....	.....
		Platformer	1,500 bbls.	.....	Under Constr.	1957	.....	.....	.....
		Desulfurization	1,500 bbls.	.....	Under Constr.	1957	.....	.....	.....
Standard-Vacuum	Altona	Alkylation Unit	1,700 bbls.	.....	Complete	.....	.....	Kellogg	KIC
Phillipine Islands									
Shell (Philippines)	Manila	Refinery	.....	.....	Negotiating	.....	.....	.....	.....
Standard-Vacuum	Manila	Refinery	21,000 bbls.	$35,000,000	Negotiating	.....	.....	.....	.....

* First appearance in tabulation † Added capacity

NOTE:

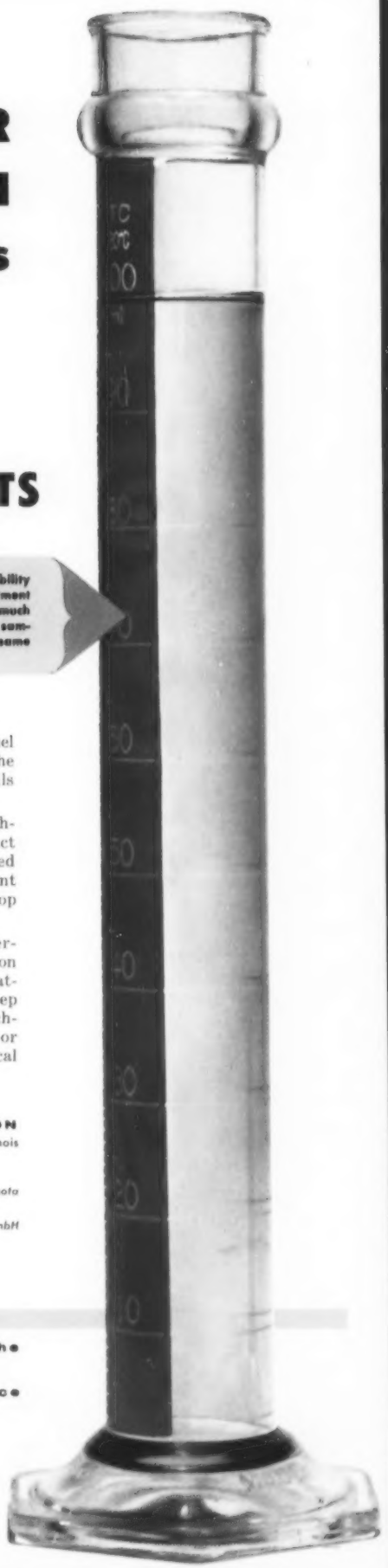
Armistead—George Armistead & Co.
Atlantic—Atlantic Ref. Co.
Austin—Austin Co.
Badger Mfg.—Badger Manufacturing Co.
E. B. Badger Ltd.—E. B. Badger & Sons Ltd.
E. B. Badger Pty.—E. B. Badger & Sons Pty., Ltd.
Barnes—W. M. Barnes Co.
Bechtel—Bechtel Corp.
Beck—Henry C. Beck
Blaw-Knox—Blaw-Knox Co.
Braun—C. F. Braun Co.
Breda—Breda Electromaccania Locomotive
Brown & Root—Brown & Root Construction Co.
Buckner—F. J. Buckner Corp.
Calif. Res.—California Research Corp.
Can. Kellogg—Canadian Kellogg Co.
Cat. Constr.—Catalytic Construction Co.
Chemico—Chemical Construction Co.
Ch. Pro.—Chemical Process, Inc.
C. B. & I.—Chicago Bridge & Iron Co.
Chiyoda—Chiyoda Chemical Engineering & Construction Co., Ltd.
C. & I.—Chemical & Industrial Corp.
Consd. Eng.—Consolidated Engineering Company
Craig—A. F. Craig & Co.
C.T.I.P.—Compagnia Tecnica Industria Petroli
D & Z—Day & Zimmerman
Delta—Delta Engineering Corp.
Dresser—Dresser Engineering Corp.
Ebasco—Ebasco Services, Inc.
E&A—Ehrhart & Arthur, Inc.
Esso—Esso Research and Engineering Co.
Edeleanu—Edeleanu Gesellschaft M.B. H.
Etabadger, S.A.—Etablissement Badger, S.A.
F&C—Farnsworth & Chambers Co., Inc.
Ferguson—H. K. Ferguson Co.
Fish—The Fish Engineering Corp.
Fluor—Fluor Corp.
Foster Wheeler—Foster Wheeler Corp.
Gas Plant Constr.—Gasoline Plant Const. Corp.
Girdler—The Girdler Co.
Girdler (Canada)—Girdler Corp. of Canada, Ltd.
Graff—Graff Engineering & Equipment
Graver—Graver Construction Co.
Grebe & Doremus—Grebe & Doremus Process Co.
Gutte-Hutte—Gutehoffnungshuette
Hercules—Hercules Powder Co.
Hudson—Hudson Engineering Corp.
H.W.P.—Head Wrightson Process, Ltd.
Hydrocarbon—Hydrocarbon Research, Inc.
Hydro M—Hydrocarbon Mineralool G.m.b.H.
Hydro E—Hydrocarbon Engineering S.A.R.L.
Kaiser—Kaiser Engineers
Kellogg—The M. W. Kellogg Co.
Kellogg P A—Kellogg Pan American
KIC—Kellogg International Corp.
Kidde—Walter Kidde Engineers Southwest, Inc.
Koch—Koch Engineering Company
Koppers—Koppers Co., Inc.
Lummus—The Lummus Co.
Macco—Macco Corp.
Mannix Gill—Mannix Gill, Ltd.
McKee—Arthur G. McKee Co.
M-C & S—Merritt-Chapman & Scott Corp.
Olsen—O. L. Olsen
P. A. HydroRes—Pan-American Hydrocarbon Research Co.
Parker—Parker, Steffens & Pearce
Parsons—The Ralph M. Parsons Co.
Phillips—Phillips Petroleum Co.
Power Gas—Power Gas Corp., Ltd.
Pritchard—J. H. Pritchard Co.
Procon—Procon, Inc.
Quaker—Quaker Valley Constructors
Russell—Russell Engineering Corp.
Rust—Rust Engr. Co.
SBA—Soc. Belge de L'Azote et des Produits Chimiques du Hardy.
SD—Scientific Design
S & B—Singmaster & Breyer Separator-Nobel Co.
Soc. Mob.—Socony-Mobil Oil Co.
Southwestern—Southwestern Constr. Co.
Sohio—Standard Oil Co. of Ohio
Stearns-Roger—Stearns-Roger Mfg. Co.
Sunland—Sunland Refining Co.
S & W Badger Div.—Stone & Webster Engineering Corp. Badger Process Div.
S & W Canada Ltd.—Stone & Webster Canada Ltd.
Swco—Southwestern Engineering Co.
Tears—Tears Engineers
Tecnider—Tecnica Idrocarburie Derivati
Tellepsen—Tellepsen Construction Co.
Texaco Dev.—Texaco Development Corp.
Texaco—The Texas Co.
Texas Natural—Texas Natural Gasoline Corp.
Trec—Refinery Engineering Co.
U.O.P.—Universal Oil Products Co.
Vucan—Vulcan Engineering Div.
J. G. White—J. G. White Eng. Corp.

STOP COLOR DEGRADATION in distillate fuels

WITH *Nalco* FUEL OIL TREATMENTS

Pronounced color degradation and sludging tendencies evident in this distillate fuel appeared *after only* 2½ *months* storage.

Despite extreme instability of the oil, Nalco treatment was effective. Note much lighter color of treated sample . . . same oil, same storage period.



COLOR degradation is a sure profit-cutter in fuel oils . . . but Nalco stabilizing treatment is the low-cost way to *stop* color degradation, keep oils refinery-fresh looking and acting.

Samples illustrated were refined from a highly sour crude; T.C.C. processed. Finished product was very unstable and color degradation occurred quickly in storage. Addition of Nalco treatment has greatly increased stability . . . helped stop both color degradation and sludge formation.

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THREE MEN AND A BUOY *in Search of Oil*

The men are Cities Service geologists, the buoy a marker used in undersea oil exploration.

That this search involves great expense, everyone agrees. That it will prove successful, no one can guarantee—since the odds for exploratory drilling are nine to one against a discovery. The Cities Service oil seekers, however, continue to chalk up impressive records in both land and sea exploration. Records such as 1955's one-out-of-three success ratio for test wells . . . far above the ratio for the oil industry.

Here are other 1955 records: A new peak in production and sales of petroleum products, with sales up 17% . . . a 6% increase in natural gas sales . . . an all-time high in stockholders' equity . . . construction of an ultramodern Cities Service research laboratory to assure that this dynamic growth continues.

The growth of Cities Service is planned not only in the company's interests, but on the broader basis of what benefits the nation as well.

We think it's a good plan.

CITIES SERVICE

Progress through Service

Reviewing New Books . .

Heating, Ventilating, Air-Conditioning Guide, 1956, prepared by the American Society of Heating and Air-Conditioning Engineers. This edition, the society's thirty-fourth, gives particular attention to the presentation of heat transmission coefficients of building materials. An important result is that the design values for conductivity and conductance are included for many more materials than in any other previous Guide. More tables make it easy to compute the effect of adding air spaces or insulations to walls, ceilings or floors.

Other material which has been rewritten is that concerned with automatic control and a description of current control equipment using the latest nomenclature.

The technical data continues to be presented in 53 chapters grouped under seven sections: Fundamentals, Human Reactions, Heating and Cooling Loads, Combustion and Consumption of Fuels, Systems and Equipment, Special Systems and Instruments and Codes. As in earlier editions of the Guide, the 24 x 32 inch ASHAE Psychrometric Chart is included.

(American Society of Heating and Air-Conditioning Engineers, 62 Worth Street, New York 13, 1176 pages, $12.)

Atomic Energy, a new Soviet journal in English translation. This journal, published by the Academy of Sciences of the U. S. S. R., will appear in six issues a year. Associated Technical Services, a firm of translators and publishers, expect the journal to include articles and reviews of the latest achievements in the peaceful use of atomic energy. The subjects to be covered will include:

- Atomic Physics—Research reactors, accelerators and experimental techniques.
- Power Generation—Reactors, metallurgy, fuel technology, heat transfer media, chemical and economic aspects of various processes.
- Raw Materials—Prospecting, extraction and processing.
- Application of Radioisotopes—In biology, medicine and industry.
- Safety Measures—"Hot" laboratories, waste disposal, dosimetry and handling problems.

(Associated Technical Services, P. O. Box 271, East Orange, N. J., six issues, $85.)

Alkyd Resins for Vinyl Finishes, Part II—Atmospheric Resistance, by S. B. Crecelius. A study, carried on at the Naval Research Laboratory, was undertaken to establish the type of alkyd resin which would give the best performance when used in combination with vinyl resin as topside coatings for Navy ships.

Several series of alkyd resins were prepared containing varying percentages of phthalic anhydride, different fatty acids (soya bean, dehydrated castor, linseed, and mixtures of these), and polyhydric alcohols (glycerol, pentaerythritol, ethylene glycol, sorbitol, and mixtures of these). Panels were exposed under several tests, including salt spray.

The long-term outdoor weathering test indicated that the maximum corrosion resistance for the glycerol products is at the 28 to 30 percent phthalic anhydride level with little difference shown in regard to fatty acid used.

The outdoor test also showed that pentaerythritol products gave the best performance at the 24 percent phthalic anhydride level. The glycerol-sorbitol mixtures performed about the same as the straight glycerol products at 26 percent phthalic anhydride content.

(Office of Technical Services, Department of Commerce, Washington 25, D. C., 17 pages, 50 cents. Order PB 111824.)

Underground Storage of Liquid Petroleum Hydrocarbons in the United States, prepared by the Interstate Oil Compact Commission. This two-part publication, complete with illustrations and tabulations, is the result of approximately four years' study by the IOCC Research Committe, working in cooperation with state committees throughout the U. S.

Part I summarizes the general conditions for underground storage which apply throughout the U. S., dealing primarily with the geologic and engineering aspects of underground storage.

Part II is a compendium of state reports describing storage projects now in operation and possibilities for other storage facilities in 42 states.

(Interstate Oil Compact Commission, P. O. Box 3127, Oklahoma City 5, 104 pages, $1.)

Petroleum Refining with Chemicals, by Kenneth A. Kobe and V. A. Kalichevsky. This book is an advanced account of the various problems encountered in refining and finishing petroleum products, including the use of additives for improving the quality of products, testing methods and refining with chemicals and solvents.

Research men, as well as plant operators and supervisors, should find the book of value. It contains chapters on emulsion and on interpretation of testing methods, topics seldom presented in concise manner. Explanations are given of other subjects, such as the theory of lubrication, usually omitted in standard college courses for chemical enginers and chemists.

Both authors have been frequent contributors to PETROLEUM REFINER. Dr. Kobe is a University of Texas professor of chemical engineering; Dr. Kalichevsky is a consulting chemical engineer with Magnolia Petroleum Company at Beaumont.

(D. Van Nostrand, Inc., 120 Alexander Street, Princeton, N. J. For Sale by Gulf Publishing Company, P. O. Box 2608, Houston 1, Texas. $14.50.)

Modern Chemical Processes, Volume 4, by the Editors of **Industrial and Engineering Chemistry.** This is the fourth volume in a series intended as a perpetual inventory of U. S. chemical technology. Two of the 19 chemical processes covered will be of interest to members of the petrochemical industry. They are for the production of French synthetic detergents and p-Xylene, both from petroleum.

(Reinhold Publishing Corporation, 430 Park Avenue, New York 22, 202 pages, $5.)

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As Management Sees It . . .

Accident Control Through Supervision

Safety programs will work better under good instructors able to train others as part of the over-all safety effort.

Alfred Lateiner
Consultant, Safety and Foreman Training

AN AGGRESSIVE safety effort can cut refinery accidents in half—*if it is properly planned*. In turn, reduced accident rates will produce:

- Better industrial relations.
- Increased production.
- Decreased operating cost.
- Higher morale.
- Improved community and public relations.

With these incentives it is obvious why refinery accident rates have shown a steady downward trend since 1949. In that year there were 7.46 injuries for each million hours worked, compared with 5.5 injuries in 1955. Even so, last year's injury ratio was up over 1954 when a low of 5.36 injuries was reported.

The fact that refinery accidents showed an increase last year points up the need for an even more aggressive safety effort than is now being employed. This can be accomplished by (1) making a more concentrated effort to determine and eliminate the cause of accidents and (2) improving safety supervision.

Determining the cause—Every injury is a *result* and every result must have a *cause*. Injuries are the immediate or direct *result* of accidents. Accidents are directly *caused* by one of three things: Human failure—mechanical failure—or a combination of these two factors.

Approximately 80 percent of all accidents are caused by human failure. Only 20 percent are caused by mechanical failure.

Why do people act unsafely? Why do they often create or permit unsafe conditions to exist? There are three basic reasons:

1. Improper attitude—disregard for instructions, direct violation of safety rules, indifference, wilful neglect—accounts for 70 percent of all unsafe acts.

2. Lack of knowledge or skill accounts for about 25 percent of all unsafe acts.

3. Poor physical or mental condition accounts for the rest.

These are the personal defects that cause a person to act unsafely. A close check into the chain of events that led up to an injury would reveal that these unsafe personal factors originated somewhere in the person's background. For example—home conditions, improper diet, insufficient rest, personal habits, previous education and experience.

This is the inflexible chain of events that causes injury. To lower accident rates, the chain must be broken or controlled.

In examining the events it becomes clear that the logical point of attack is the unsafe act or condition which immediately precedes the accident. Experience has proved that little can be done about the background of the individual. Unsafe acts or conditions can best be eliminated where administrative and executive control are exerted by the person in charge whether it be the plant manager, supervisor or foreman.

Improving Supervision

Foremen and supervisors are closer to the unsafe acts or conditions than anyone else on the supervisory level, therefore can make decisions close to the point where safety problems arise. These men have the opportunity and the authority to control the behavior of their workers and the immediate work conditions. They must be trained in the why and how of this authority.

To guide the person in charge as to what an unsafe action is or an unsafe condition may be, the following list is provided. This safety check list broadly describes all possible unsafe actions or conditions that may exist in any situation. It is based on a careful study by the American Standard Association and has been in effective use in many successful accident prevention programs:

Human Failure

1. Operating without authority, failure to secure or warn. Includes an unauthorized operation such as jumping on a moving train, running someone else's equipment without permission, trying to operate an elevator or any direct violations of existing procedures or failure to secure, to tie or batten down or make fast or a failure to warn, which includes letting another person know when something you are doing may put them in danger.

2. Operating at an unsafe speed—going too fast, too slow, unsafe shortcuts, driving a car too fast or too slow, operating a machine at an unsafe speed, running instead of walking or running down stairs.

3. Bypassing safety devices. Includes disconnecting, misadjusting, or in someway short-circuiting a sign, signal or mechanism which has been designed for the safety of the individual. (For example, tying up the safety

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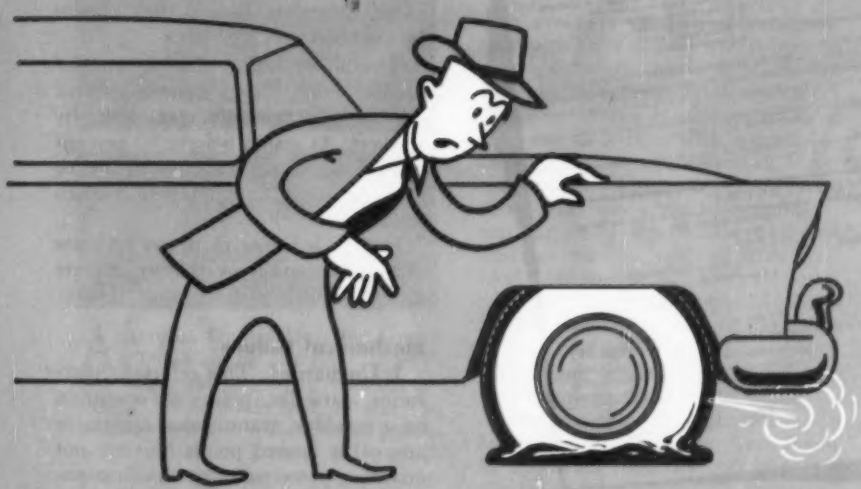

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Supervisor's Report of An Accident

Unit Name

Name of injured employee:

Location

Date of Report

Suggested form to be used by supervisory personnel in reporting an accident—as based on the accident prevention program outlined on these pages.

interlock level so that an elevator can be operated with the door open.)

4. Using unsafe equipment. Involves using equipment that has become defective through wear and tear or abuse. In the same category we include using the equipment unsafely, in which case the equipment itself is safe but the method of operation or use of such equipment is unsafe. For example, a man using a wrench that is bent or rusty, teeth worn or jaws spread, is using unsafe equipment. The same man using a wrench in perfect condition to drive nails is using the equipment unsafely. The failure is with the man rather than with the equipment in this case. Also in the same classification, is using hands instead of equipment, as in the case of a man using his hands instead of a brush or stick when there is some danger to the hand.

5. Unsafe loading, placing, mixing or combining. Unsafe loading would be excessive loading, loading too high, loading in such a way as to create a top-heavy load or loading over the safe load limit either on a vehicle, platform, conveyor, truck or other piece of apparatus, unsafe placing would be placing tools in such a position that they might roll or fall. Placing equipment in aisle spaces or in the line of travel, placing hands at dangerous points of operation in, on or between equipment. Combining refers to unsafe combining of acids and water.

6. Taking unsafe position or posture. Lifting improperly, lifting in a position with the body twisted, standing in the right of way or line of travel, referring to the position of the body in relation to other objects and the posture of the body in relation to the work that is being done.

7. Working on moving or dangerous equipment unnecessarily. This involves oiling, cleaning or adjusting equipment while it is in motion, reaching into, freeing or straightening material that is being processed.

8. Horseplay of various types such as teasing, fooling, practical joking, quarreling, distracting, etc.

9. Failure to wear personal protective devices—goggles, gloves, safety shoes, respirators, and other specific clothing items to protect the individual when the hazard itself cannot be confined.

The above listing of nine types of unsafe action give a cross-section of the various practices committed by workers. As stated before, 80 percent of all injuries are traceable to one or more of these nine types of human failure.

Here is a listing of the eight types of unsafe conditions that contribute or lead directly to accidental injuries:

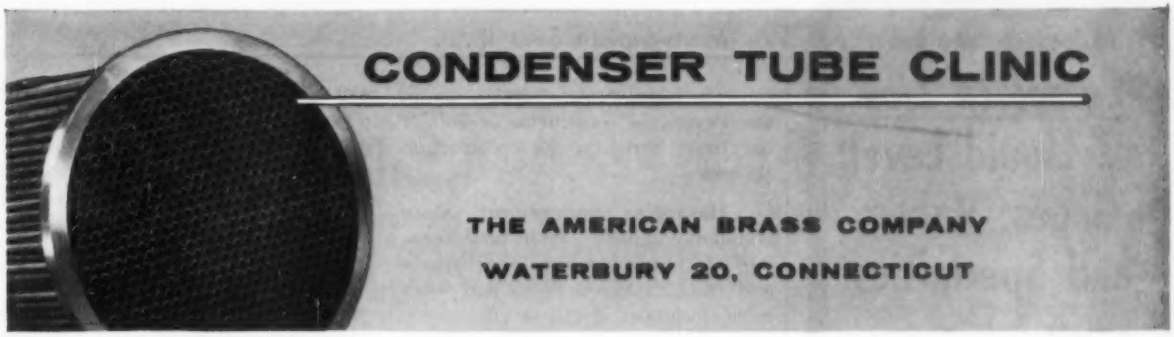
Mechanical Failure

1. Unguarded. This refers to platforms, catwalks, points of operation on a machine, transmission apparatus and other hazard points that are not guarded, protected, fenced off or enclosed in some way.

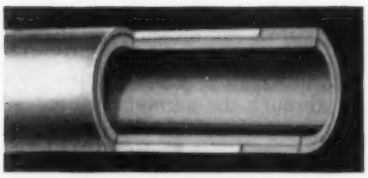
2. Inadequately guarded. Similar to the first category but involving flimsy, loose, improper, insufficient, or incomplete method of guarding. For example, if a guard railing on a bridge were loose, flimsy or defective, a person leaning on the railing would fall to certain death or injury. This type of unsafe condition is even worse than a completely unguarded situation where the individual would notice the obvious danger.

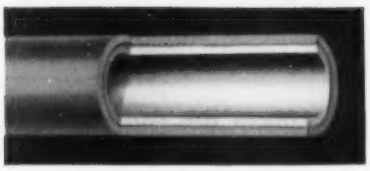
3. Defective. Tools, gear, equipment, vehicle, buildings or any kind of material that people may be using, that is in some way worn, torn, cracked, broken, rusty, bent, sharp or splintered through wear and tear or abuse.

4. Unsafe design or construction. The defects traceable to the blue print or plan. In a building, the architect, or in a machine, the designer may



How two-tubes-in-one can help you solve complex corrosion problems





Edited by James T. Kemp, Metallurgical Engineer

ANACONDA Duplex Heat Exchanger Tubes are for two types of service—where the corroding characteristics of fluids inside and outside the tube are best met with different metals or alloys—where internal or external pressures, or the pressure-temperature combinations, are too great for a nonferrous tube alone. In the latter case, an Anaconda copper alloy with the required corrosion resistance is placed outside or inside a steel tube—and the pair is drawn together. The finished Duplex Tube has the chemical properties required for the more corrosive fluid handled—plus the needed strength.

TWO SEPARATE CORROSION PROBLEMS. A Duplex Tube of steel with copper or a copper alloy inside is used, for example, in exchangers or condensers handling water in the tubes and ammonia or a fluid with appreciable amounts of ammonia in the shell. Moist ammonia attacks copper and all of its alloys, and may cause stress-corrosion cracking. Stresses may be due to applied loads or may be residual from cold working of the metal. Steel, however, is not susceptible to such action by ammonia. Thus the nonferrous tube is shielded and can perform its normal function of giving long service life and efficient heat transfer on the "water side."

Other combinations of coolant—or heating fluid—and "stream" are found in petroleum refineries and chemical plants, in which differing properties are required inside and outside an exchanger tube. Here two nonferrous metals may be combined—a Cupro Nickel and Admiralty, for example.

HEAT TRANSFER. Duplex Tubes have thermal transfer characteristics somewhere between those of the two metals used. Each face of the tube has the receptivity-emissivity of its metal. The metal-to-metal interface is so intimate it offers little resistance to heat flow.

FERRULES. Duplex Tubes can be supplied with ferrules of the same composition as the inner tube (see upper illustration), replacing a short section cut from the end of the outer tube. This ferrule prevents excess corrosion of the ends exposed in the exchanger channel. The ferrule should be long enough to be securely rolled in when the Duplex Tube is expanded into the tube sheet.

TECHNICAL ASSISTANCE. The American Brass Company's metallurgical engineers and its sales representatives throughout the country are available to help you in the selection of the Anaconda Condenser Tubes to meet your problems. Write: Technical Department, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 6678

ANACONDA®
Tubes and Plates for Condensers and Heat Exchangers

PHYSICAL PROPERTIES OF ANACONDA CONDENSER TUBES*

ALLOY	Tensile Strength, psi	Yield Strength at .5% Elongation Under Load, psi	Elongation in 2", %	Rockwell Hardness, B Scale	Density, Lb. per Cu. In.	Thermal Conductivity, B.T.U./Sq. Ft./In./Hr./°F. at 68° F.	Average Coefficient of Linear Thermal Expansion per °F. (77-572 F.)
Arsenical Admiralty-439	52,000	22,000	60	6-45	0.308	768	.0000112
Ambraloy-927	60,000	27,000	55	35-65	0.301	696	.0000108
Ambraloy-901	60,000	30,000	60	30-60	0.295	552	.0000099
Cupro Nickel, 30%-702	55,000	22,000	50	30-60	0.323	204	.0000090
Cupro-Nickel, 10%-755							
Light Annealed	44,000	22,000	46	25	0.323	314	.0000093
Light Drawn	60,000	57,000	15	68			
Red Brass-24	42,000	15,000	50	0-30	0.316	1104	.0000104
Ambronze-421	46,000	20,000	55	0-30	0.316	830	.0000102
Phosphorized Arsenical Copper-108							
Light Drawn	40,000	35,000	20	20-50	0.323	1344	.0000098
Hard Drawn	54,000	50,000	8	50-70			
Phosphorized Copper-103							
Light Drawn	40,000	35,000	20	20-50	0.323	2364	.0000098
Hard Drawn	54,000	50,000	8	50-70			

*Note: The above values are approximate and should not be used for specification purposes. *Light annealed except as noted.*

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have included unsafe design or in some cases the constructor or builder may have erred in the construction process.

5. **Hazardous arrangement.** More commonly named "poor housekeeping" includes blocking aisle spaces and exits, cluttered floors and work areas, improper layout or congestion, etc.

6. **Unsafe illumination.** Lighting conditions that contribute to accidents include: Too much light, not enough light, glare, wrong color, direction or intensity.

7. **Unsafe ventilation.** Concentrations of toxic dusts, fumes, vapors and gases. Silica, chemicals, paints, solvents, heated metals and other materials found in many activities may cause occupational injury if not properly confined or exhausted.

8. **Unsafe clothing.** Improper attire for the job in hand often causes the mishap. Loose belts, flapping sleeves, trouser cuffs, jewelry and worn out shoes provide the jumping off point for many a serious injury.

If the people in charge of safety would become more familiar with the accident causes described above, they would be able to institute control measures for effective safety. Control measures are not complicated or difficult. Foremen, supervisors and officials should follow a simple pattern that divides into two areas: Control of (1) human failures, (2) wrong conditions.

First let us consider the unsafe *actions* which cause most of the injuries; the pattern for controlling human behavior:

1. **Stop** the unsafe action,
2. **Study** the situation,
3. **Instruct** the violator,
4. **Train** by repeated instructions, and,
5. **Discipline** by good example.

This corrective procedure will not eliminate all wrong actions in any group of people but if followed conscientiously by the one in charge it will effectively reduce the number of exposures to accidental injury. If people in charge recognize the causes of accidents and know what steps to take for prevention, a 50 percent cut in injuries will result.

The pattern for controlling unsafe conditions is:

1. **Remove** the hazard or when that is not possible.
2. **Guard** or protect or barricade the danger point, or when that is not possible, be sure to.
3. **Warn** all people who may be exposed in the area; if none of these possibilities exist then be sure to.
4. **Notify** the proper supervision through the normal channels depending on the conditions prevailing.
5. **Follow up,** after a reasonable amount of time has elapsed and

Meet the Author

ALFRED LATEINER, a New York management consultant, has conducted supervisory training courses for more than 40 companies, including U. S. Gypsum Company, Tide Water Associated Oil Company, General Foods Corporation, Mergenthaler Linotype Company, Mohawk Carpet Mills, Stanley Tool and the U. S. Naval Shipyards. He also was chairman of public-employe safety on the President's Committee of Occupational Safety; general chairman of the Public Employe section of the National Safety Council, and supervisor of in-plant training courses in the School of General Studies Extension Program sponsored by the City College of New York. From 1948 to 1951 he was consulting director of special training for the City of New York.

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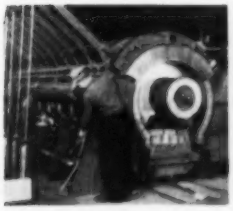
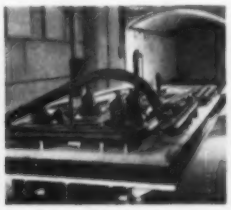


Pipe being heated to exact temperature required for proper bending

Skilled team completes bend in six minutes with pipe close to 2000°F



Fabricated piping, bending operation completed, enters stress-relieving furnace

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Ultrasonic testing of a weld on heavy wall pipe

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As Management Sees It . . .

the unsafe conditions remains. You are entitled to an answer—either something is being done or some reason why no corrective action is under way.

Training trainers. The most rapid and effective way to ensure the application of safety programs is to gather together the nucleus of good instructors who will in turn be able to train others.

The training of trainers is indeed a vital phase in the over-all success of a safety program, but it is a phase which can only be envisaged once the management has been won over to the idea of safety as a vital factor in production and employe morale.

It is not enough to just develop good training programs for supervisory personnel. There should be periodical refresher courses and advanced instruction in safety. By a continuing program of training it is possible to anticipate accidents. Often accidents can be pre-determined and preventive action can be taken. This is a technique, almost a science, which is quite well established and known.

An aggressive safety effort is aided by the establishment of a safety committee. It must be frankly stated that too often the safety committee is a body which sees that the requirements of the law are carried out and the necessary reports provided as required by the State. This is not a good operation. In the first place, a permanent committee of 10 to 12 men is not ideal because it is essential to include the workers and management in the safety program. This can only be done by having a rotating committee in every production shop or area whereby new and old members are always sitting side by side and becoming familiar with all aspects of the safety program.

Even in the central safety committee of a large refinery there should be a continuous rotation of members, so that all top management personnel are at some time or another directly involved in the safety work being undertaken. Only in this way can safety become an integral part of the refinery's activity. ##

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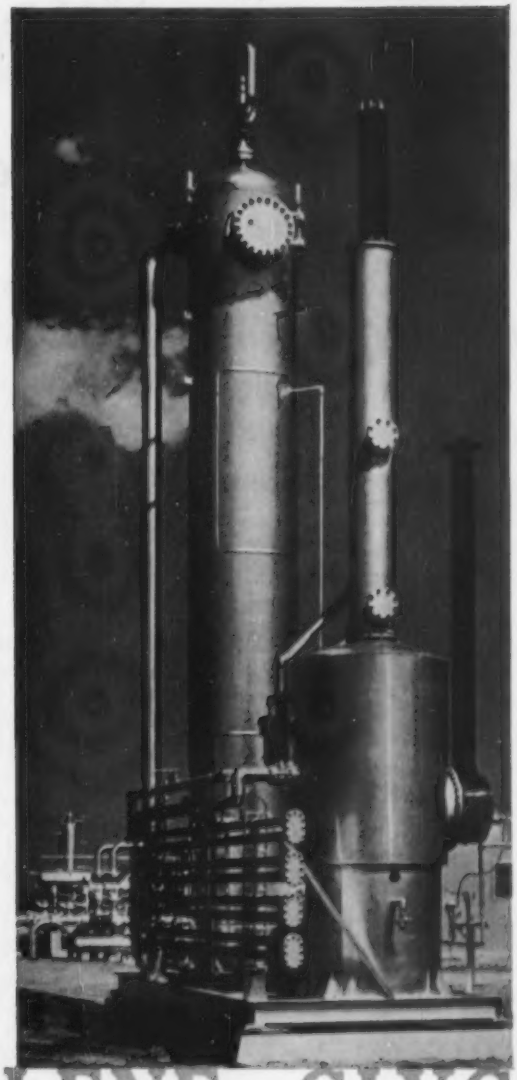
Photo Courtesy of Blaw-Knox Company



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If you currently use TEG, write for a typical analysis, quotation and free sample of our material. It's extremely low in iron, chlorides, acidity and water.

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Management's 'Forgotten Men'

The author describes two excellent ways to solve executive manpower problems: (1) Recognize your source—middle management. (2) Do something about it by creating a sound management development program.

Joseph M. Trickett
Coordinator, Management Development Food Machinery & Chemical Corporation
San Jose, California

MIDDLE MANAGEMENT is an important area of modern industry—and in it are likely to be found the "forgotten men" of management.

These men are neither chief executives of their organizations, nor are they currently in front-line management or supervision. Yet they constitute a pool from which industry must recruit its top flight executives.

In its accelerated effort to find executives, modern industry must depend on management development. In turn, management development depends upon middle management in a more or less logical pattern. To follow this evolution in the thinking of modern management, three related questions must be reviewed:

1. Why is management development of increasing and vital importance in American business?
2. What is the role of middle management in a company's management development?
3. How is personal development involved in management development?

Why Management Development? It is no accident that, during the past few years, most of the well-known companies in America have become interested in management or executive development. In fact, over 75 per cent of all large companies in the country have some formal approach to the development of their executive material. About three-fourths of these have had management development programs for no longer than seven years.

Several factors have combined to bring about this new interest in executive growth and development. First, there is the changing picture in business itself. The job of management in business today is markedly different from what it was 15 years ago.

Throughout industry of all types and sizes, within all functions in business, there are new demands upon managerial skill and ability. The very impact of a new and fast-changing technology, the changes in the marketing and distribution picture, and the highly dynamic and volatile human relations problems are familiar. And these are only the beginning. As Peter Drucker has pointed out in his challenging look at *The Next Twenty Years*:

"The greatest educational need may well be in management . . . the "intuitive" manager is obsolete; and "experience" will not be a very reliable guide . . . indeed it would be hard to find an institution of learning where he could acquire today the education he needs to be a manager tomorrow. But, in the sense of being able to handle systematic knowledge, he will have to be highly educated.

"This educational job will have to be done, to a very large extent, in and by the business itself . . ."

The second fundamental change within American industry which has emphasized the need for developmental activities is the transition from a proprietary-to a professional-management group.

One qualified observer, Robert McMurry, points out that this change began right after World War I and is continuing through the present. He says that the problem of finding and developing qualified, professional managers is a fairly new one; that until World War I, there was relatively little need for managers of this kind since most businesses were managed by their owners.

The trend during the past 25 years toward the separation of ownership from management, plus the increasing complexity and size of business operations, has fostered the growth of the professional manager. Not only does this new professional manager know that he must be particularly and specifically trained to handle what he calls his *"trusteeship responsibilities,"* but he knows that he has a continuing and pressing responsibility to keep up in his chosen profession.

There is a third related factor in this new interest in executive growth —it has even been likened to a managerial renaissance. A few years ago, several qualified observers, among others, pointed a change in the outlook, in the attitude, of existing managers. This is generally shown by a new will-

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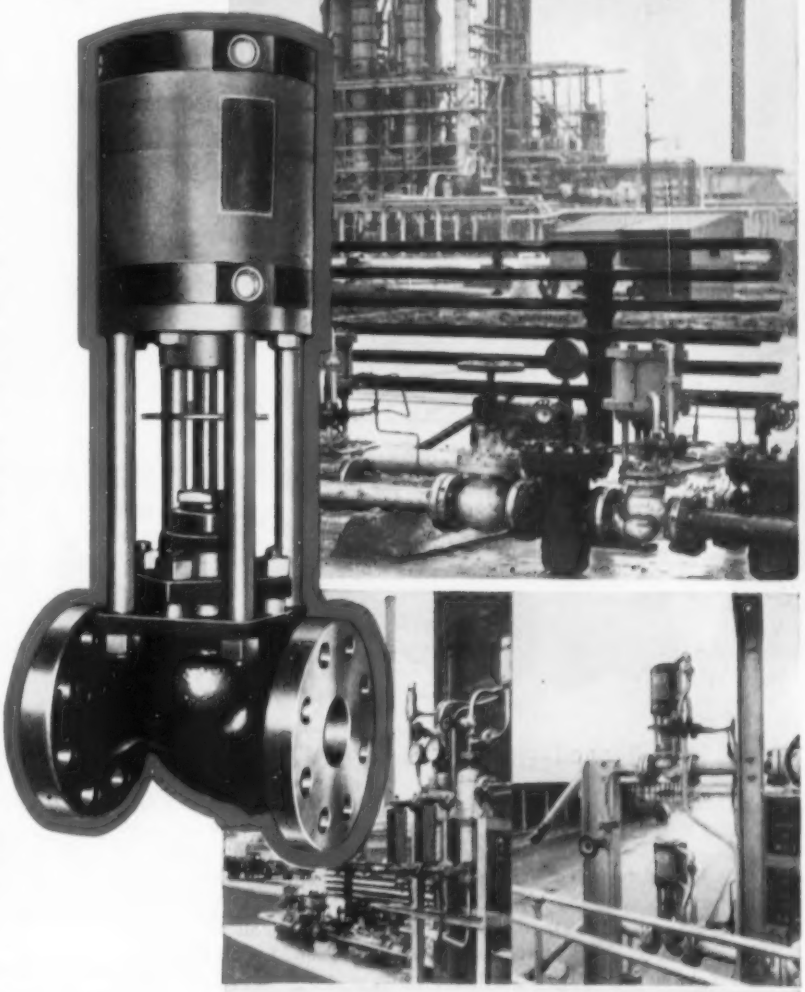
AIR-OPERATED VALVES

The fact that the Klinger valve has no seat but is sealed by resilient packing rings which are compressed round a sliding piston, means that power is only required to move the piston from one position to another and no power is required to maintain the valve in the closed or open position. Valves are manufactured with bronze, forged or case steel bodies, screwed or flanged, with stainless steel pistons and spindles as standard, in sizes from ¼" to 6" bore. Tapped air connections are provided at each end of the air cylinder. The valves have been designed for operation with an air supply at a pressure of about 70 p.s.i., although in certain circumstances it is possible for the valves to operate at pressures down to 50 p.s.i.

Klingermatic air-operated valves are ideally suited for remote control of filling lines, emergency valves, where rapid operation is desired and such similar applications.



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2-stage unit

With Dependable COFFIN Turbo Feed Pumps

Matched pump, turbine and governor are compactly designed and precision built as an integral unit to assure years of dependable performance—in minimum size, with low steam consumption. Widely used for boiler feed service in refineries, chemical plants, paper mills and general industry, the well-known line of Coffin Turbo Pumps offer Volumetric Ranges to 800 gpm, Discharge Pressures to 1500 psig, Steam Temperatures to 950° F., Exhaust Pressures to 200 psig, and Liquid Temperatures to 325° F. For special installations these ratings may be exceeded.

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As Management Sees It . . .

ingness to learn, a new recognition of room for personal growth and improvement, a seeking of methods to improve one's personal efficiency and effectiveness.

The phenomenal growth in variety and number of management programs in colleges and universities throughout the country, overwhelming demands for enrollments in seminars and programs of such organizations as the AMA and the N.I.C.B., and the great increase in demand for management literature of all sorts are symptomatic of this new interest, of the managerial enlightenment.

What is Management Development? Any discussion of the importance of management development today requires some definition of terms, for, like most of the terminology of modern business administration, there is a great deal of confusion and even contradiction.

In the minds of many, management development means something to be done today to young and inexperienced men to make them qualified to assume managerial responsibilities tomorrow.

To others, management development means "sending two men each year to Harvard" or some other such university program.

To a few, the term means replacement charts, age-of-incumbent analyses, manning tables for the very top positions in the company hierarchy. And to some it means the training classes, outside written material sent to individuals, or other efforts to improve quality of company foremanship or supervision.

Management development, of course, means all of these things.

Management development is a continuous process or activity which is concerned with selection, organization, maintenance and improvement of management personnel throughout the organization. As such, it is a threefold responsibility—of each individual, for his self-development; of each boss, for the development of his subordinates; of the company as a whole, to provide each boss with adequate tools, procedures and guidance.

Objectives and Philosophy. It has been pointed out again and again,

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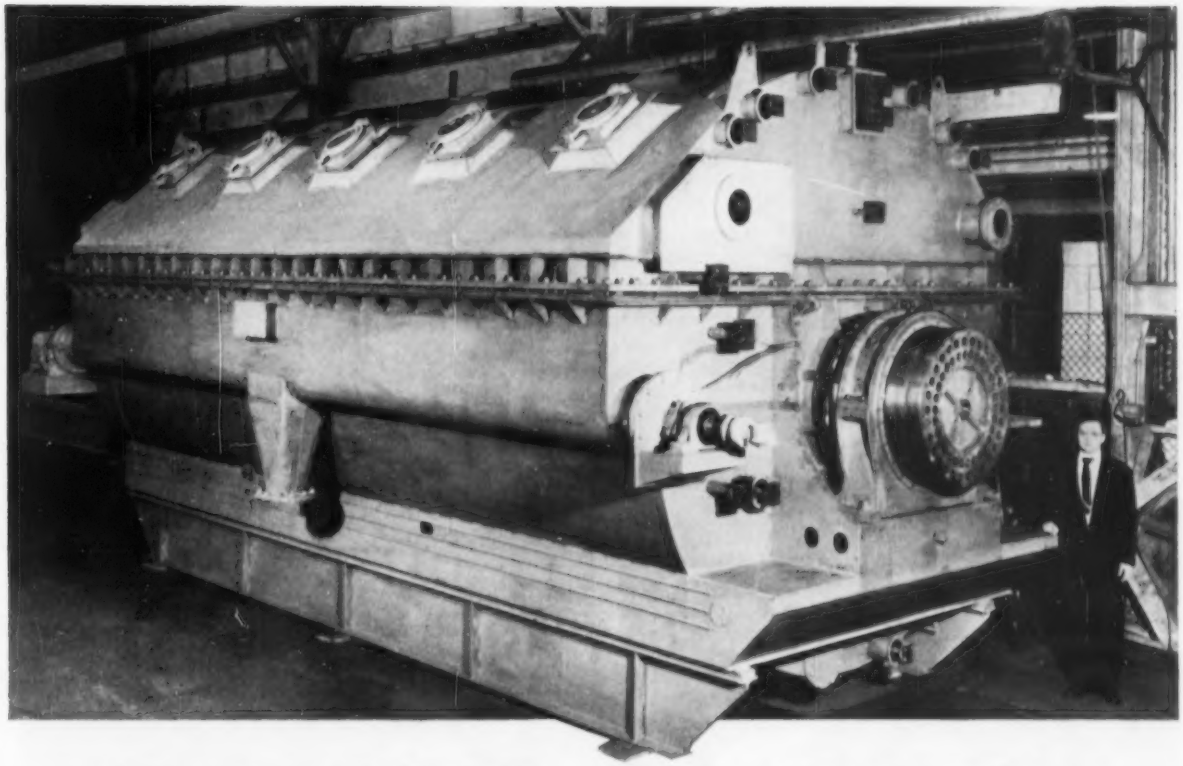
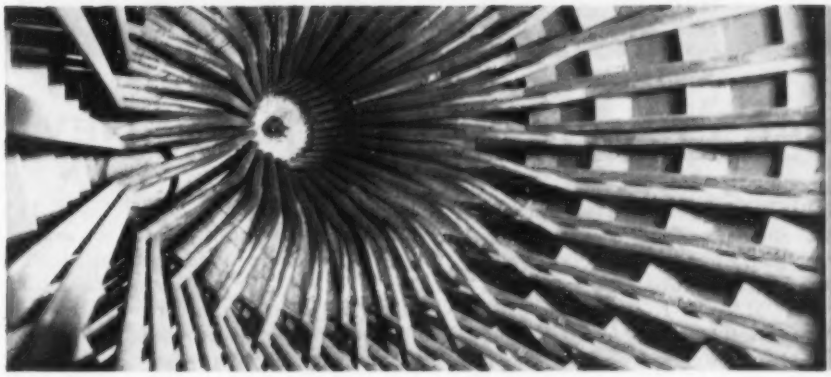


World's LARGEST Petroleum Filters



One of six of the Oliver De-waxing Filters.

Internal drum exposure showing the pipes leading from the filter sections to the automatic valve in the trunnion.

Manufactured for a large mid-western refinery, each of these six MEK Oliver De-waxing filters measures 10′ in diameter, 22′ 3″ in length and has a filtering area of 700 square feet.

Oliver De-waxing Filters were selected for this installation because of large process capabilities, unique filtrate valve design, and a well-engineered internal drainage system.

Dorr-Oliver manufactures a complete line of filters for the petroleum industry. Other "World's Largest" . . . an Oliver pre-coat installation for breaking slop oil emulsions . . . and filtration stations for contact clay removal from lube stocks.

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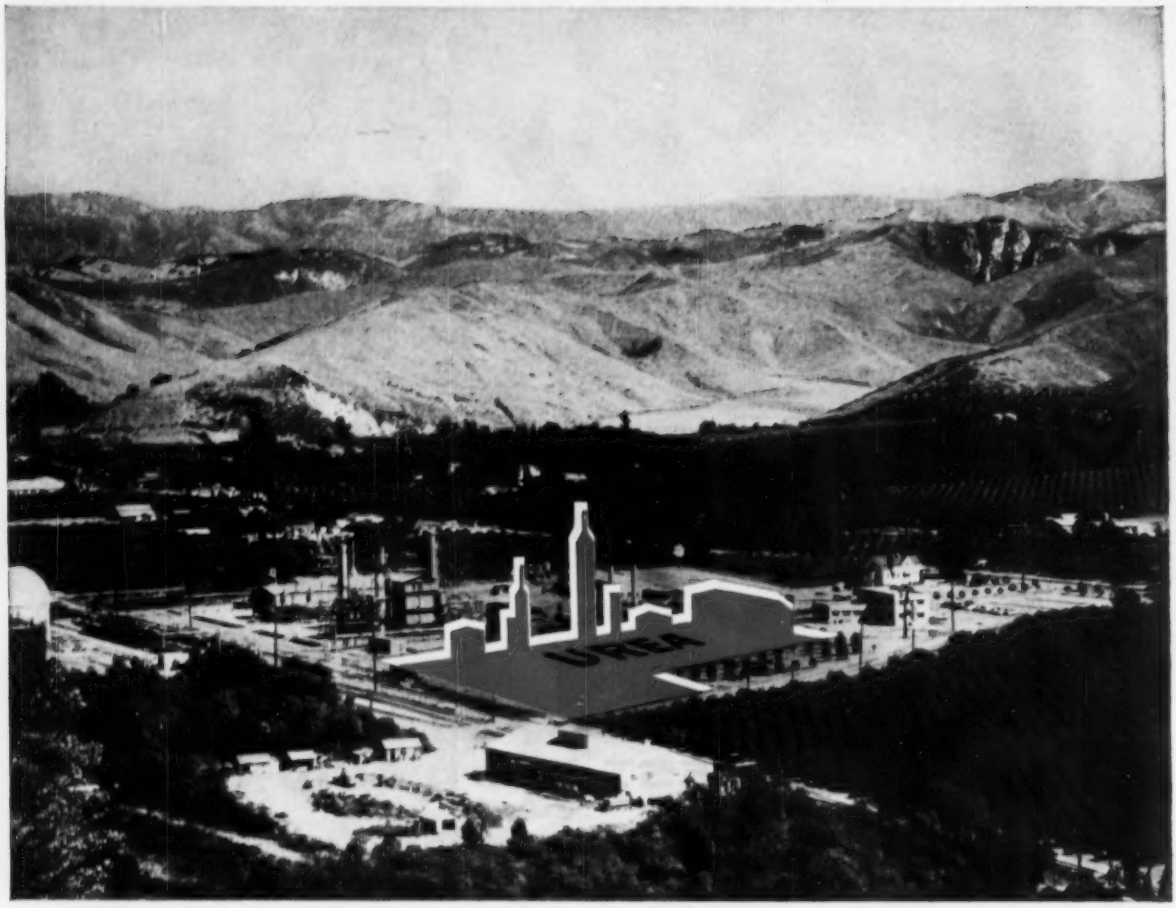

SHELL CHEMICAL IS ADDING SOMETHING NEW

Next door to its ammonia plant at Ventura, California—in the heart of a rich agricultural area, Shell Chemical Corporation has picked the logical location for its new urea plant. The M. W. Kellogg Company worked with Shell Chemical in engineering the project, and is now well ahead with construction. The plant will be completed this fall. M.W. Kellogg also engineered and built Shell Chemical's adjacent 150 ton/day ammonia plant, from which raw materials will be piped into the urea facilities.

Designed to produce 100 tons of high purity urea per day, the Ventura plant will be the chemical industry's first urea manufacturing facilities on the West Coast. It will also be the first urea plant in the entire United States to use a new process which, in addition to being considered the most efficient yet developed, overcomes the severe corrosion problems encountered with conventional urea processes.

If your company is considering new or expanded production of petrochemicals—especially of urea, ammonia, ethylene, phenol, or butadiene—M. W. Kellogg's long and broad experience with hydrocarbons in these areas is your assurance of low initial and operating costs, as well as high yields.

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As Management Sees It . . .

by many recognized management authorities, that effective management development is more a philisophy of management that it is a system of forms and procedures. Yet many companies seem to have adopted and adapted the trappings without formulating, accepting, and internalizing the necessary philosophy. Likewise, many companies, which have attempted to do something formal about the development of their management personnel, have failed to define or even think through the objectives of whatever they are setting out to do.

A great many even formally-defined and stated objectives or purposes of executive development activities are inadequate or severely limited in scope. A little time spent in clarifying such objectives and in making them generally known throughout the organization would be well justified by larger returns from such activities.

Putting the Philosophy to Work. Even well-crystallized beliefs and stated objectives will not, in themselves, provide a sufficient guide for all managers at all levels and all locations—there must be some means to put the philosophy to work. Therefore the following steps or phases of putting an effective management development philosophy to work within the organization are proposed:

1. A broad statement of policy to crystallize the philosophy and synthesize determined objectives.

2. Certain procedures and tools to implement this policy. Three basic tools are of prime importance: an individual experience record; a performance appraisal or review procedure; and a specific plan or program for each individual.

3. Participation by top management.

4. Provision for application within the entire management team.

5. Identification and use of available management-development resources.

6. Almost unlimited subject-matter coverage.

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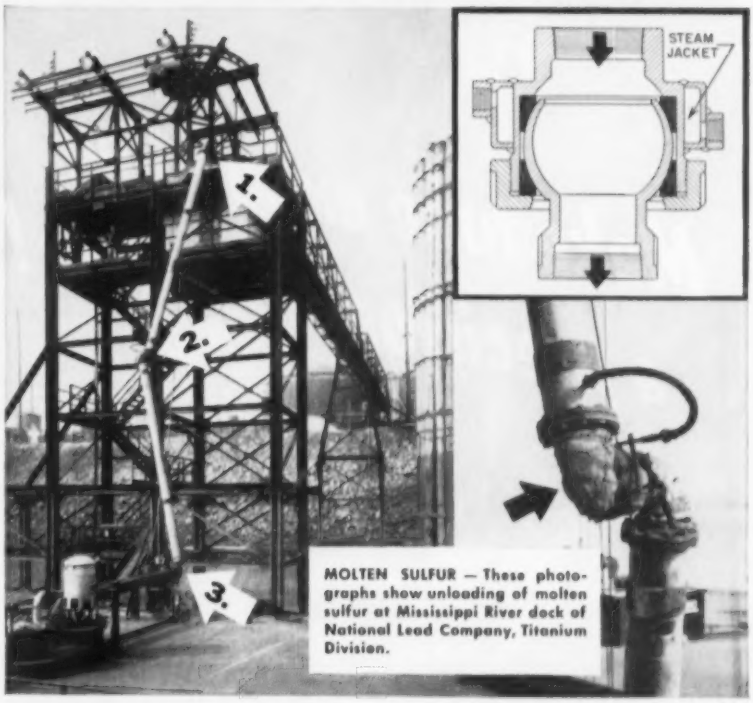

MOLTEN SULFUR — These photographs show unloading of molten sulfur at Mississippi River dock of National Lead Company, Titanium Division.

UNLOADING LINE
Heated for Free Flow!

HOT steam is the secret of handling sulfur as a liquid at barge loading and unloading docks. Barco's new Steam Jacketed Flexible Ball Joints are an integral part of the splendidly engineered installation shown above. A traveling crane raises and lowers pipe made flexible with Barco Joints. This arrangement accommodates river stages varying up to 40 feet. This permanent, maintenance-free, labor-saving installation eliminates the problems of rapid deterioration and frequent maintenance encountered with hose.

For recommendations on how to use Barco Flexible Ball Joints in loading lines handling oil, chemicals, gasoline, alcohol and other fluids, ask for a Barco engineering field representative—located in principal cities.

FEATURES

COMPLETE LINE — Barco Steam Jacketed Flexible Ball Joints are now offered in 2", 3", 4" and 6" sizes.

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FLEXIBILITY — The ball provides more than 30° total angular movement in any direction.

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ENGINEERING RECOMMENDATION—Ask for a copy of new catalog 2158 on "Barco Flexible Ball Joints for Piping."

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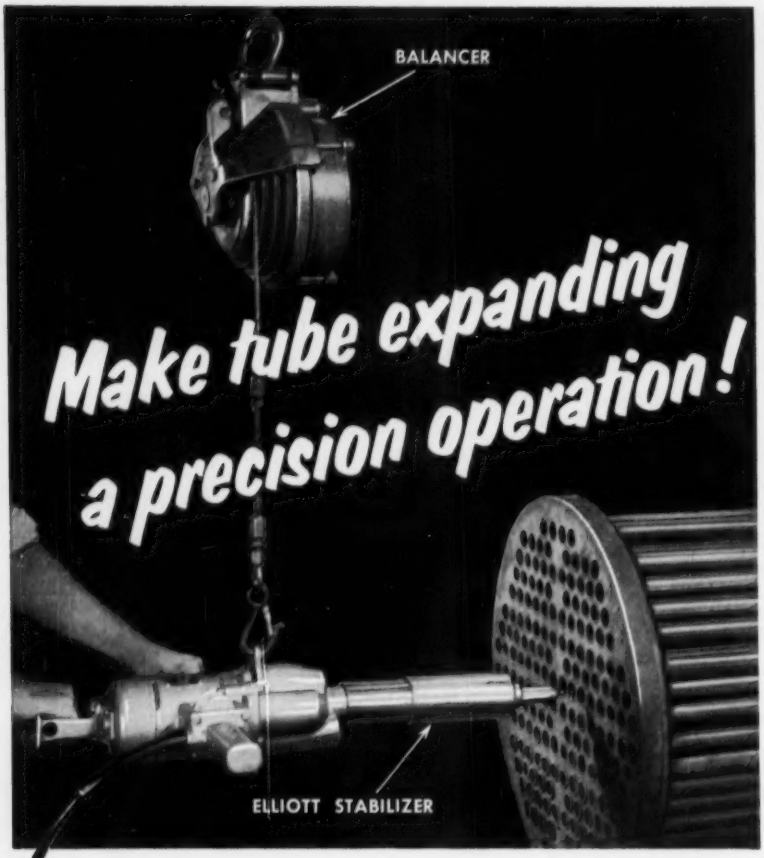
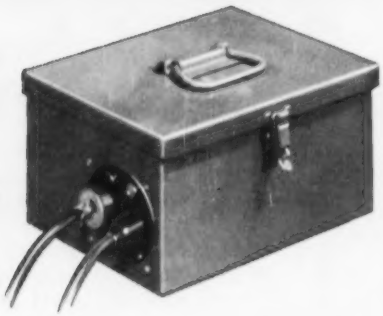


THE ELLIOTT ELECTRICAL CONTROL



Get tight, uniform tube joints everytime and get them fast. The Elliott Electric Control, a torque-limiting device designed for use with any standard tapping motor, automatically balances outside voltage variables (without the need of a separate voltage regulator), controls the torque, and tells you when the tube has been rolled tight.

Speed the operation too with balancer and the Elliott Stabilizer which takes the wobble out of tube rolling. It centers and holds the expander case and cage, allowing operator to keep both hands on the motor. Full details in Bulletin Y-40. Address Elliott Company, Lagonda Division, Springfield, Ohio.

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term action, with feed-back controls to assure such continuity.

The Role of Middle Management. During the last few years, much concerning top management and front-line or supervisory management has been heard and read. Very little has been written or spoken about the several levels or layers of management responsibility which lie between top, general company management and management at the work level.

Middle management can best be defined by exclusion—by excluding those few individuals who have interfunctional, company-wide responsibilities and those who have immediate and direct supervision of work being done at any location or within any function.

This leaves the individuals involved in the several levels of management who, in most companies, are respon-

Meet the Author

JOSEPH M. TRICKETT has been coordinator of management development for Food Machinery and Chemical Corporation at San Jose, Calif., for the past year. Previously, he was with the American Management Association in New York, where he conducted a nation-wide survey of management-development activities. His other experience includes six years as dean of the School of Management at San Francisco's Golden Gate College; five years as director of organization management with Columbia Steel Company, and similar activities with Standard Oil Company of California. Dr. Trickett is a graduate of Washburn University and holds M.B.A. and Ph.D. degrees from Stanford University.

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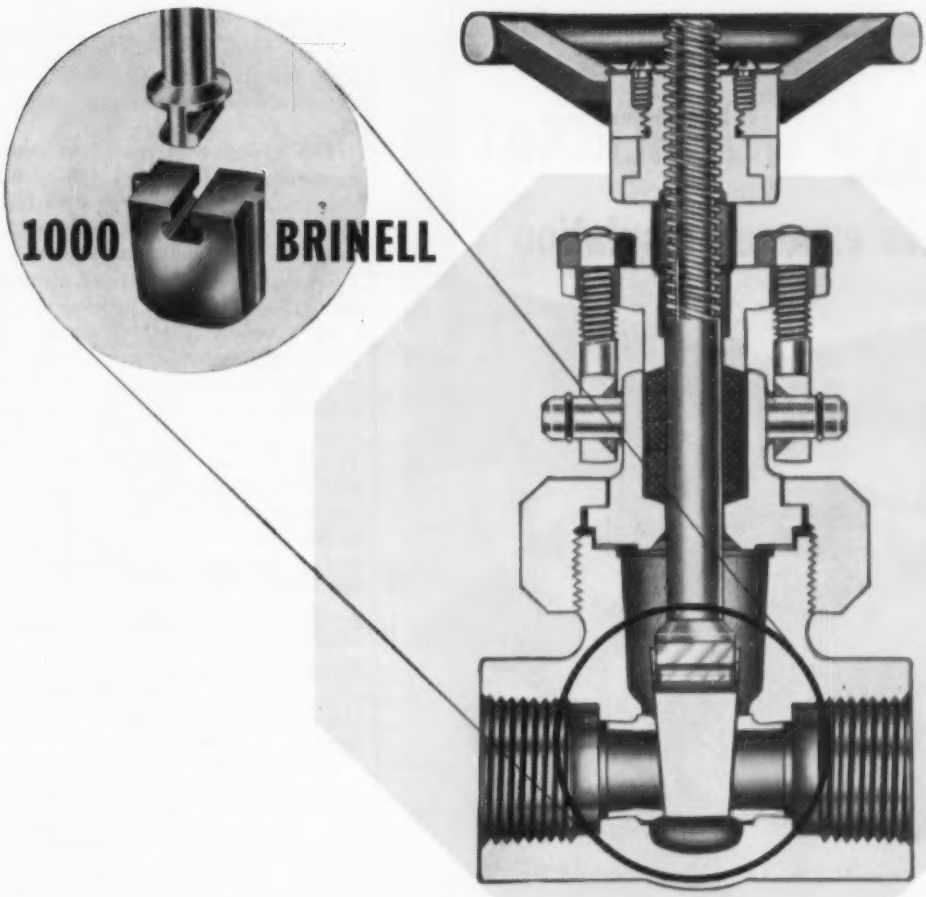

Fig. 1221

Stop Galling with the hardest valve wedges you can buy

OIC VALVES

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Highly resistant to erosion and corrosion

Here's a wedge as hard as flint . . . so hard that it's undamaged by pipe cuttings, scale or grit. It's the only trim we know of which will successfully withstand the simultaneous attack of the three valve-destroying agents—corrosion, erosion, galling. This wedge is *13% chrome stainless steel hardened up to 1000 Brinell.*

Specify the OIC 1221 gate or 1621 globe where you need the extra rugged nature of forged steel. They are recommended for steam service up to 800°F...oil service up to 1000°F. Or, use these same valves for hydraulic service up to 2000 lbs.

Write for Form 195 for specifications on the OIC forged steel line.

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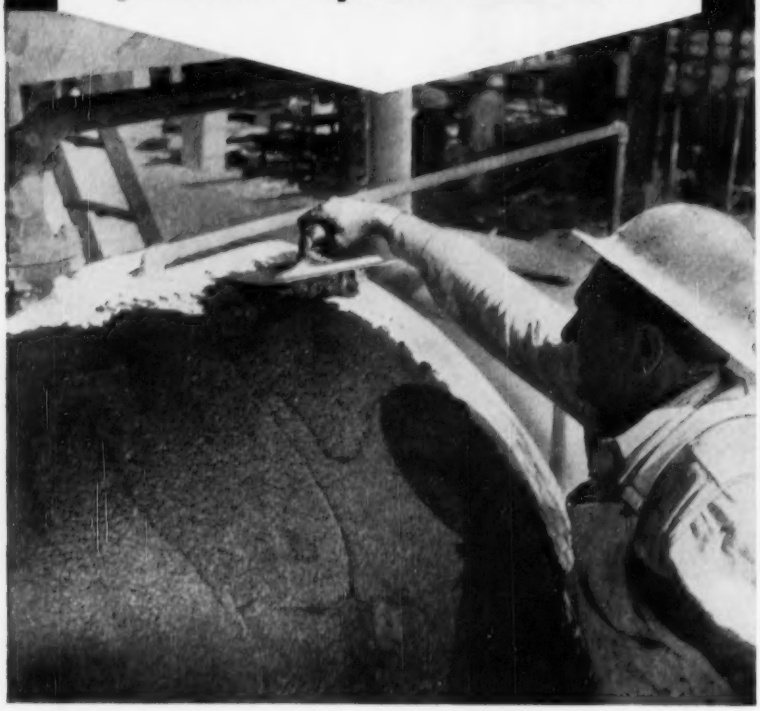
protects exposed insulation



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Modern refinery and plant design places many major insulated vessels "in the open." You can maintain the efficiency of your insulation with easy-to-apply Laykold Weathercoat.

Weathercoat is a fibrated asphalt-base material of easy troweling consistency that dries to a black, remarkably tough and tenacious coating. A majority of the leading refineries are regular users of Weathercoat.

A new product: Mastic Weathercoat, a bodied material, for use wherever economy demands the application of a *single*, thick layer.

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sible for particular functions, locations, facilities, or products (things).

The "forgotten men" in management. A few years ago it was quite fashionable to refer to the foreman, the first-line supervisor, as "the forgotten man" in management, but since that time a variety of foreman training activities has developed.

In a relatively minor number of instances, companies have begun to recognize that more is needed in developing an effective organization than foreman or supervisory training. Frequently, the chief things wrong with the foremen's attitudes and behavior were the foremen's foremen—middle management.

The diminution of real authority at the working level and the creation of a wide variety of staff experts have served to augment the fact that individuals in management who actually may need broadening, horizon-clarifying attention most are many of those in middle management.

For example, most progressive companies have given some consideration to the way the over-all organization structure of the company is set up, its basic divisional and departmental setup. Likewise, there has been frequent analysis and attention to areas of responsibility and lines of authority at the work level—usually dictated by the nature of the work processes.

There has, however, been relatively little attention to the problems of organization planning within the several levels of responsibility which here are called middle management. A part of this neglect is reflected in the lack of developmental activities which are carried on within this group. This runs the gamut from membership in professional societies and attendance at management meetings (well-used by members of top management) to specific developmental and improvement classes for supervisors (most frequent at the lowest level). Yet, management development cannot be genuinely effective within an organization unless the essential interlocutory role of middle management is recognized and utilized.

Of course the developmental role cannot effectively be played either up or down, unless executives are

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75 years ago and 12 years before Motion Pictures were invented

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Time was . . . when motion pictures were little more than a quick succession of instantaneous photographs. An oil well was a hole in the ground, a small steam engine, rude derrick, and pump.

Today motion pictures have matured into the splendid effects of Technicolor and Cinemascope, and the American oil trade into the world's largest producer of crude petroleum.

Having grown up alongside the American petroleum industry for the past 75 years, KOVEN takes pride in having helped this industry achieve faster, more efficient output at lower costs. By manufacturing individualized petroleum equipment economically and according to the exact specifications of petroleum manufacturers, KOVEN has itself succeeded in becoming one of this country's foremost contributors to petroleum progress.

With experience of this kind KOVEN feels confident it can help turn *your* production problems into production solutions. Call or write for a consultation with a trained representative, and send for Bulletin #550. There's no obligation.

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KOVEN equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E., A.P.I. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; light and heavy fabricated piping and plate exhaust ducts. Shop and field erected storage tanks to 2 million gallons. High vacuum testing on liquid oxygen storage tanks.

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stainless steel • aluminum • monel • nickel
inconel • all clad materials *Fabrication to all A.S.M.E. Codes*

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How to pack up your packing troubles . . . and smile, smile, smile

Replacing the packing in your pumps is a necessary evil—and an expensive one. Maintenance time comes high, but downtime for emergency repacking is worse.

One of the outstanding features of Dean Brothers standard centrifugal pumps is the way they're designed to overcome packing wear. For instance, shaft deflection is a serious cause of packing wear. The greater the shaft diameter and the shorter the shaft overhang, the less the deflection. So Dean Brothers engineered the shaft extra large with an extra short overhang for longer packing life.

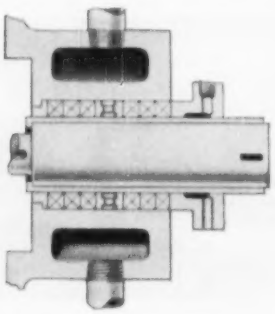
Obviously the more rings of packing, the less wear on each ring. So the stuffing box was designed for six rings (plus lantern gland)—one more ring than most pumps. And when a mechanical seal is used for high temperature pumping, the integral stuffing box accommodates it, too—another neat bit of cost-saving engineering. And to insure adequate cooling of the packing in high temperature services, the water jacket *completely encircles the full length of the stuffing box.*

Every part and every feature of these pumps have been engineered into an integral unit with standard, interchangeable parts to make them the best pumps in the long run and the lowest in overall cost.

If you'd like to pack up your packing troubles, you'll be interested in full information about all Dean Brothers standard centrifugal pumps.* Send for Circular No. 184A.

**Series 10, Series 20 and Series 30—to 7,000 gallons per minute capacity.*

Partial section showing water jacket encircling full length of stuffing box. Also note *six* rings of packing plus lantern gland in center. Width of gland is same as two rings of packing.



DEAN BROTHERS PUMPS INC.

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As Management Sees It . . .

willing first to look to their own development.

Dr. Ohmann of the Standard Oil Company of Ohio and one of the country's authorities in this field of personal development has put this point succinctly: ". . . emphasis in . . . training has usually been on training the other fellow—his needs and shortcomings being more apparent than our own . . . Let's start management development with ourselves. Certainly, we have some responsibility for developing others, but I sometimes think we could accomplish more if we just worked on ourselves."

Personal Development. Earlier it was emphasized that management development is man development and that each man, each individual, must want to develop. Actually, it is almost a phycho-physical truism that growth and development of an individual must continue; when growth process and growth desire stop, degeneration, leading to decay and death, begins.

Of course, there are many facets of a being in which the apex in this growth curve is reached relatively early, particularly true of the physical side of life. There are some old wives' tales which indicate that this same phenomenon is true regarding the mental-emotional side of life. A you-can't-teach-an-old-dog-new-tricks philosophy has handicapped the personal development of many in business. Not only does it keep some bosses from giving developmental attention to certain of their subordinates, but it keeps many individuals from doing anything for themselves.

This myth should and must be exploded. A person can grow and develop and change, in attitude and in behavior, just about as long as he really wants to do so and in the general direction he basically picks out. In fact, it might be said that a person is going to change and develop for better or for worse anyway, so it behooves him to make this change as positive, as purposeful and as useful as possible.

Self-Analysis for Self-Development: The writer believes that all that is done in appraisal or perform-

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What are your refractory castable problems ?

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- Abrasion and Erosion?
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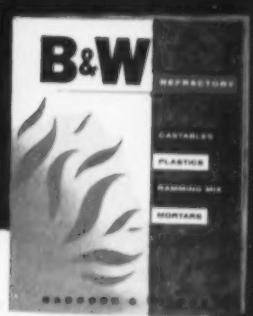

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BABCOCK & WILCOX

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ance review activities is aimed at helping the individual to see himself and thus to help himself. Thus, part of the process of coaching and counselling which goes on between boss and subordinate involves getting each man to appraise himself. If each person can say, "Yes, I should improve or change that aspect of my performance . . . What can I do about it?", then real development is well on the way.

Six Keys to Personal Development. At this point the reader may well ask: "So what? What do I do next about my personal development?". Here are six keys to follow:

1. Begin now to recognize your chosen profession of management. Such recognition implies a keeping up in your profession. There are evolving philosophies and procedures and techniques with which a bona fide professional manager must be familiar; he gets familiar by participating in management societies and programs and by reading widely, though selectively, in the field of management.

2. Look to your personal development on a continuing basis. This includes your ability to write and speak effectively. There is a growing feeling among many top executives that no one should be permitted to play an important role in management unless he is an effective speaker and writer.

Part of this, naturally, involves how and what you read. It has been well-stated, again and again, that the real leaders in tomorrow's business must be "well-educated men, not trained seals."

If you can't read rapidly enough, expose yourself to some of the techniques in written material and in evening classes on how to speed up your reading and improve your comprehension.

3. Keep in mind the big picture—see the whole forest, not just your particular tree. Don't fall into the trap of a specialist who knows more and more about less and less. Don't lose sight of the over-all objective of your organization. Constantly keep your personal and functional objectives in line with these over-all purposes.

4. Be positive in your thinking and in your actions. Don't be defensive either about your work or about your particular qualifications. Many functional specialists tend to want to defend their particular activity. Remember, "knowledge is power" and if your knowledge is broad enough, your power and recognition also will be broad.

5. See that your practice of management with your subordinates and others in the organization is in line with your fundamental belief in good team play and effective group action. Thus, don't precipitate line-staff conflicts.

If in a staff position, remember that the basic purpose of your function is to facilitate, to improve, to assist, to service, and to advise those individuals who are engaged directly in achieving the basic objectives for which the organization exists. Staff executives with this cooperative point of view do not grasp for line authority or complain that they need more authority to get the job done.

If you are in a line job, recognize that staff people are there to facilitate your activities, in the final analysis, and that your results can be sounder, quicker, easier through the proper use of staff assistance. An effective line executive knows how to use staff organization.

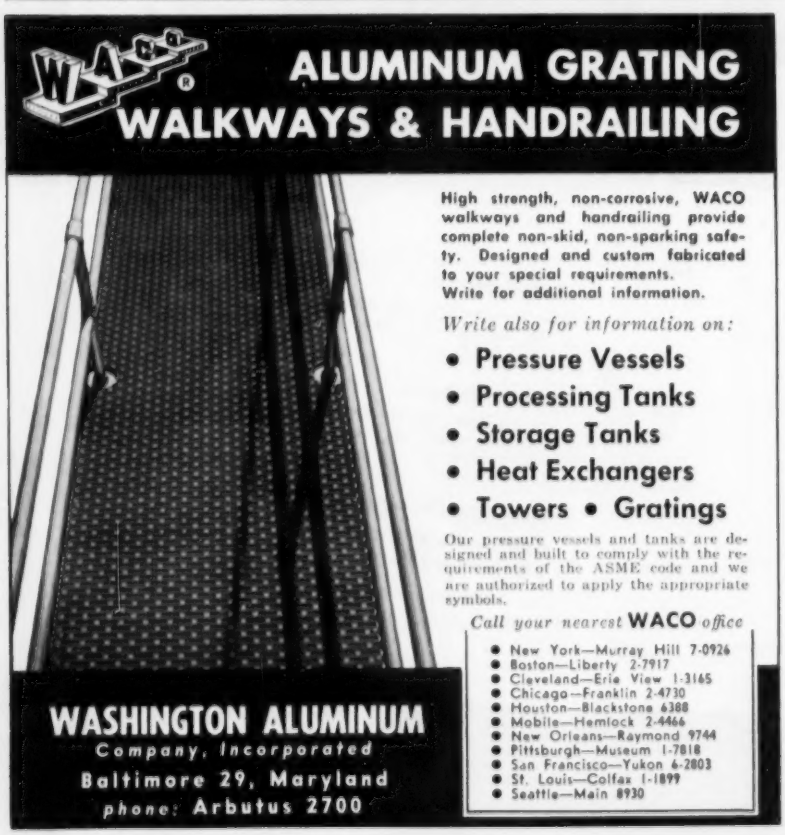
6. Get acquainted with yourself. If you would know others, you must first know yourself. This is not to advocate a morbid introspection; it is to advocate a mature, balanced outlook.

To make a good manager, begin with a good man, and each man must start this management development himself.

As previously emphasized—management development is really self-development. Only through individual self-recognition and development can expect a management leadership be provided in business which is genuinely able to get things done through people.

ACKNOWLEDGMENT

This article is based on a series of lectures presented at the Management Institute for Executives, sponsored by the School of Industrial Engineering and Management of the Oklahoma Institute of Technology, Oklahoma A. and M. College, Stillwater, Okla., April 19, 1956.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What's Happening . . .

. . . in the Industry

Rathbone Stresses Need For International Trade

M. J. Rathbone, president of Standard Oil Company (New Jersey), said in Chattanooga recently that a "two-way street" of international trade is "an absolute must" if the U. S. is to maintain its dominant position in the work.

He said as the U. S. expands industrially, international trade will be the key to the country's "pressing need" for new materials.

At the same time, he said in a commencement address at the University of Chattanooga, international trade will help the country find "new markets" in those countries that are struggling to raise their standards of living and require our machinery, manufactured goods and food.

Rathbone, who heads the world's largest industrial concern, also said international trade will promote "peace and welfare of nations" by demonstrating the strong points of democracy and free enterprise.

New Law Clears Way For Refinery on Indian Land

A bill has been passed and signed into law, clearing the way for construction of one, and possibly two, refineries on the lands of the Tulalip Indian reservation near Maryville, Wash.

The bill was pushed through Congress on the basis of proposals by Richfield Oil Company for construction of a $50-million refinery on the reservation. Now, Union Oil Company of California also is reported as interested in acquiring a refinery site on Tulalip lands.

Under the new law, owners of certain lands on the reservation will be permitted to initiate court action for authority to sell. The measure also will permit tribal heads to sell tribal lands with the consent of the Interior department.

World Congress Sets Next Meeting in U. S.

The fifth World Petroleum Congress, scheduled for 1959, will be held in New York's Coliseum. It is expected to attract some 5000 oil scientists and others from 30 countries.

C. Eugene Davis, Kirkwood, Mo., petroleum consultant and recently-retired vice president of Shell Oil Company, will serve as general secretary of the congress.

At the fourth congress in Rome last summer, Eger V. Murphree was re-elected chairman of the organization's top governing group, the Permanent Council. Murphree, president of Esso Research and Engineering Company, is on a one-year leave of absence from his firm while serving as special assistant to the Secretary of Defense for guided missiles.

A general organizing committee set up to conduct the fifth congress consists of: F. S. Clulow, vice president in charge of manufacturing, Shell Oil Company; H. W. Field, general manager, research and development, The Atlantic Refining Company; Jerry McAfee, vice president, Gulf Oil Company; John C. Zimmer, assistant manager, Socony-Mobil Laboratories; E. B. McConnell, vice president, Standard Oil Company (Ohio); H. B. Nichols, vice president and director, California-Texas Oil Company; J. K. Roberts, general manager, research and development, Standard Oil Company (Indiana); W. C. Kinsolving, vice president, Sun Pipeline Company, and Mr. Murphree, chairman.

Nations with delegates on the permanent council are the U. S., Great Britain, France, Austria, Belgium, Canada, Germany, Mexico, The Netherlands, Venezuela and Italy.

The purpose of the congress is to analyze and discuss scientific developments affecting the worldwide petroleum industry. This is done by technical reports which number about 200 at each congress.

The organization dates back to 1900. It was not until the 1933 meeting in London, however, that the first congress was officially identified as such. The second was in Paris in 1937 and the third in The Hague in 1951.

Texaco Cleared to Buy British-Owned Company

The Texas Company has offered to purchase the British-owned Trinidad Oil Company for about $176 million, and the proposal has been approved in the House of Commons.

Involved in the transaction would be Regent Oil Company, Ltd., a British marketing concern with plans to build a refinery in southern England (see Who's Building).

The Trinidad company, formerly known as Trinidad Leaseholds, Ltd., has an interest in Regent Oil, while California Texas Oil Company, Ltd., in which Texaco has an interest, is the other owner of Regent Oil.

First Catalytic Cracker Started Up 20 Years Ago

Twenty years ago last month, the first successful commercial-scale unit for catalytic cracking of major fractions of crude to produce high yileds of high-octane gasoline went on stream at Paulsboro, N. J.

The unit employed a silica-alumina pelleted catalyst developed by Eugene J. Houdry and his associates after 13 years of research. Millions of dollars were invested in experiments and pilot studies to perfect the process.

Successful commercial operation of the first catalytic cracker at the Paulsboro refinery of what is now Socony Mobil Oil Company followed months of experimental operation to bring the unit into final adjustment. The following year, Sun Oil Company placed an automatic catalytic cracker in operation at its Marcus Hook refinery to process 12,000 barrels a day of heavy gas oil.

License Suit Settled

Settlement of a law suit in which Sunray Mid-Continent Oil Company was the plaintiff and Universal Oil Products Company, the defendant, has been jointly announced by the two companies.

The suit resulted from a patent-licensing agreement entered into in 1936 between

API-ASME Code to Be Dropped

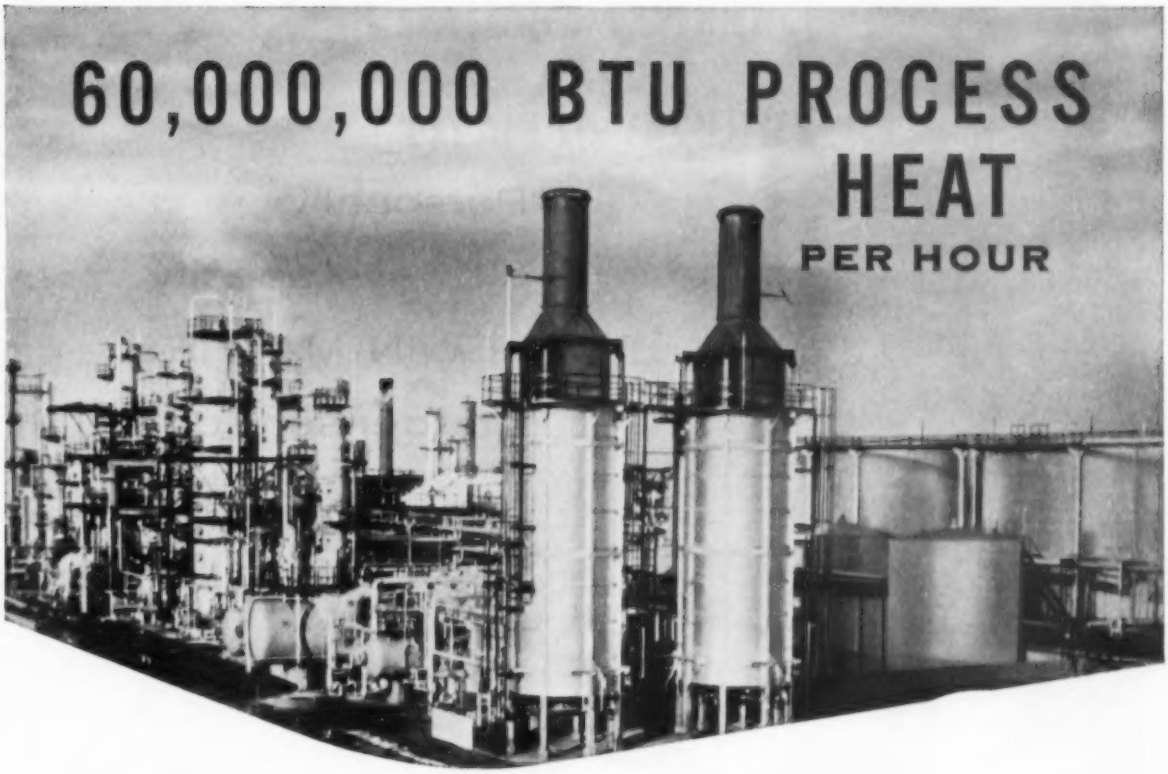
The code of standards used by the petroleum industry for more than 20 years to build and maintain pressurized production and storage facilities will be discontinued at the end of this year.

Known as the "API-ASME Code for Unfired Pressure Vessels for Petroleum Liquids and Gases," the code was formulated and published jointly by the American Petroleum Institute and The American Society of Mechanical Engineers.

The move was announced in a joint declaration by the two groups signed by their respective presidents—Frank M. Porter of the API and Joseph W. Barker of the ASME. They noted that one reason for the cancellation is the growth in scope and completeness of the ASME Unfired Pressure Vessel Code which has been expanded in recent years to cover the industry's pressure needs more completely.

The joint code, first approved in 1934 and revised four times since then, was intended to outline safe practices in the design, construction, inspection and repair of vessels used in the petroleum industry to contain liquids and gases under pressure or vacuum. These include pressure storage facilities as well as refinery equipment such as the shells of evaporators, bubble towers and separators.

In many areas, state laws require that construction and maintenance of all such equipment conform to the code.



A typical Struthers Wells CIRCULATING HEATING SYSTEM serving a major Canadian oil refinery

The Dowtherm heaters shown above are installed in the plant of a major Canadian oil refiner. The heaters are part of Struthers Wells circulating heating systems, utilizing liquid Dowtherm as the heating medium, at temperatures of approximately 700°F.

This equipment is used to supply process heat for reboilers and other heat transfer equipment, as installed in a modern lubricating oil refining operation. This type of equipment insures close temperature control and high heat transfer rates in the users. The capacity of these systems is 60,000,000 BTU per hour, making it one of the largest installations of this type.

Struthers Wells is a major supplier of circulating heating systems for both liquid and vapor service, and utilizing commercial heat transfer fluids in a wide temperature range. Hundreds of successful installations, many of them repeat orders, provide a wide background on which to base recommendations for any type of service.

Fired heaters for the direct heating of process fluids, as gas, steam, and hydrocarbons, to the highest commercial temperature ranges are also built by Struthers Wells.

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What's Happening . . .

the former Mid-Continent Petroleum Corporation, recently merged with Sunray Oil Corporation, and Universal Oil Products.

The settlement involved licensing agreements covering new refinery-processing facilities to be included in the $8-million to $10-million expansion program of D-X Sunray Oil Company, the refining subsidiary of Sunray Mid-Continental Oil.

Rifle Shale-Oil Plant Transferred to Navy

The Navy has taken over the government's oil-shale facilities at Rifle, Colo. The plant was transferred from the Interior department's Bureau of Mines to the Navy department was made after Congress failed to appropriate money to continue shale-oil research at Rifle.

The plant is on Naval oil-shale reserves. Facilities include a mine which has been producing shale, and retorting and refining equipment which has converted shale into diesel oil, gasoline and other products on an experimental basis.

The plant's retorting and refining equipment has been idle about a year, with recent work confined to mining research. This was cancelled when the Senate approved a Congress failed to appropriate funds for the new fiscal year.

The new budget also limits funds for research on shale oil at Laramie, Wyo., to about $100,000. The previous budget had allowed twice that amount. The Laramie plant, still under the Bureau of Mines, will continue petroleum research, however, with a budget of some $400,000.

Average Octane Ratings Hit All-Time High

Nationwide weighted averages of octane ratings for both premium- and regular-grade gasolines on sale at service stations climbed to new all-time highs in June.

According to Ethyl Corporation's monthly survey, the average rating for premium grades rose to 97 octane numbers, and regular grades went to 90. This represents a 0.3 octane-number increase over the May averages for both grades.

Compared with June, 1956, premium-grade gasolines had a 1.4 octane number increase, and the average for regular-grade gasolines was up 1.7.

Average tetraethyl lead contents in June were 2.58 ml a gallon for premium, as compared to 2.56 in May, and 2.32 ml a gallon for regular, against 2.30 in May.

Of the 53 cities covered in the survey, 11 reported premium averages of 97.5 or higher, with Corpus Christi, Texas, highest at 98. On regular, 16 cities showed average octane ratings of 90.5 or more, with Pittsburgh highest at 92.6.

Four Companies Announce Grants to Education

Four industry-sponsored grants to help support education were announced this month.

• The American Society for Engineering Education has awarded the first ASEE-Leeds and Northrup Foundation fellowship to a student pursuing a Ph.D. degree

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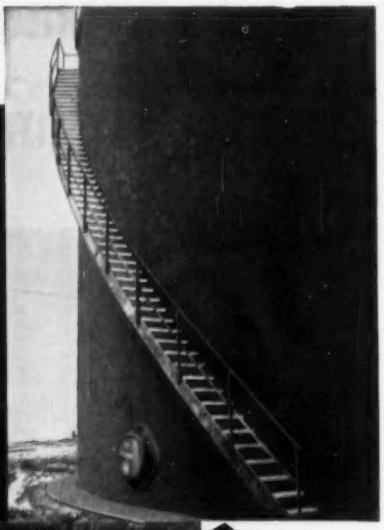

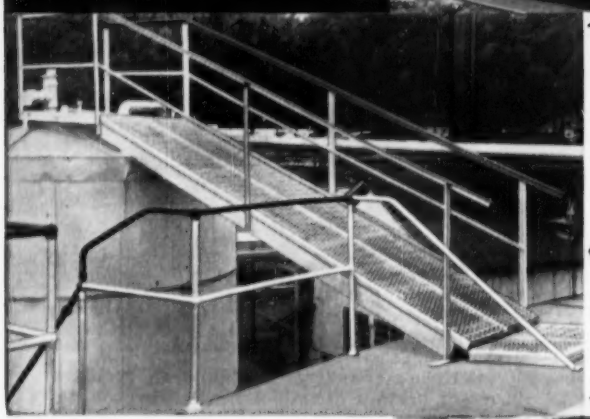

Grip-Strut circular stairway on Shell Oil tank in Portland, Ore.

See how Shell Oil uses Grip-Strut for a safe ramp between tanks.

View looking down circular stairway on Shell Oil tank shown above.

SAFETY GRIP-STRUT is the new basic material, all in one piece (including channels), not welded, riveted or expanded in steel or aluminum, in standard sizes and gauges. Safety GRIP-STRUT presents an open space, in a diamond pattern, in excess of 55% of the area for ready access of light and air and gives a positive NON-SKID footing in all directions. Ideal for work platforms, stair and ladder steps, flooring, balconies, catwalks, machinery guards, fire escapes and for original equipment safety treads.

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★ Slip proof
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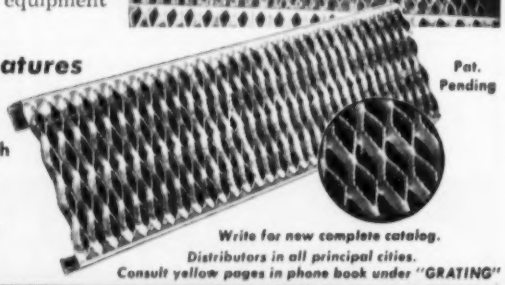

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What's Happening . . .

at Johns Hopkins University. Set up in 1955 by a grant to the society from Leeds and Northrup Foundation, the fellowship provides a three-year tenure for study leading to a doctorate in engineering.

• Meanwhile, Two one-year fellowships in chemical-engineering study, established by Fluor Foundation, have been awarded to students at the University of Southern California. The foundation is a separate corporation set up by The Fluor Corporation, Ltd., to distribute contributions to charitable and educational institutions.

• And gifts to educational institutions by The Dow Chemical Company will total $320,000 in the school year beginning next fall. The company's 1956-57 aid-to-education program will include 62 fellowships and 27 scholarships at 46 institutions. The amount to be spent next year represents a 9-percent increase over the company's present program.

• The American Oil Company, for the second year in a row, has set aside $35,500 for use in aiding privately-financed, four-year liberal arts colleges in 16 eastern states.

The company is distributing the unrestricted grants through various state and regional associations of privately-financed colleges. The funds, to be used during 1956, will be allocated to more than 140 member colleges.

Professors Attend Seminar On Petroleum Industry

A practical course in petroleum-industry operations was completed in San Francisco recently, by 18 Western college professors who participated in the sixth annual University Faculty seminar, sponsored by Standard Oil Company of California.

The two-week program included conferences with top management and other employees of the company and tours of company facilities, including those for refining and research.

Purpose of the seminar is to better acquaint the professors with the petroleum industry and to further mutual understanding between educators and businessmen in general.

In addition to the regular program each of the participants studied a particular phase of the Company's operation on which a comprehensive report including observations and recommendations was prepared.

Pollution Survey Started

A study of air pollution in the Houston area will be taken up by Southwest Research Institute. Houston's Chamber of Commerce contracted for the survey. The San Antonio research concern is expected to spend two years on the project. It will cost about $16,000.

Grace-Cosden Deal Off

The merger agreement between W. R. Grace & Company and Cosden Petroleum Corporation has been terminated. Cosden's proven reserves of crude were below the minimum 17,765,000 barrels stipulated in the agreement, and the company was unwilling to consider a lower price.

For more data on advertised products, use Readers' Service Cards, last page.

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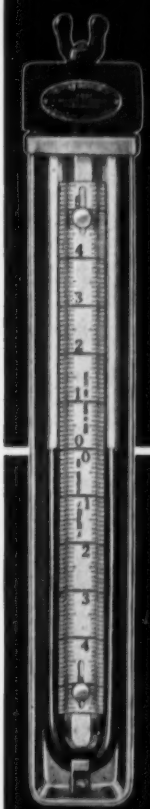

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What's Happening . . .

Dow to Buy Refinery; Plans Expansion Project

The Dow Chemical Company is taking an option to buy Bay Refining Corporation and its associated Bay Pipe Line Corporation.

Dow would build a petrochemical plant on property it owns adjacent to the Bay refinery at Bay City, Mich., to use refinery byproducts to make ethylene. The new plant, to be coordinated with Dow's facilities at Midland, Mich., will be completed in 1957.

The Bay company will continue its operations in the refining industry.

New Methods Hold Key To Super Fuels, Refiners Told

New refining processes and improved catalysts hold the keys to economical production of "super fuels" needed by automobiles coming off assembly lines in the future, the Pennsylvania Grade Crude Oil Association was told at a recent meeting in Bradford, Pa.

Henry W. Grote, assistant manager of the research and development laboratories of Universal Oil Products Company, said a "significant" proportion of the nation's total gasoline output must soon have a very high octane rating.

"Present 97 to 98 octane premium gasoline," he said, "still will not give knock-free performance in certain of the highest performance cars, amounting to 15 to 20 percent of the 1956 models."

Gasolines produced by fluid catalytic cracking can be used in reasonable amounts in premium fuels today, Grote pointed out. But, he added, much lower concentrations will be permitted in "super quality fuels required in tomorrow's markets."

"Catalytic reformates have been used extensively in recent years to produce premium quality fuels," he said. "Rapid acceptance of catalytic reforming, now totaling about 11% of the nation's crude processing capacity, has been the factor which has permitted production and marketing of the premium gasoline presently required by the industry's customers."

Grote reported it has been predicted by some that by 1960 catalytic reforming capacity may exceed 40 percent of the U. S. total crude capacity. Reforming is producing leaded gasolines of 100 octane today, and some reformers are producing fuel rated at 98-100 octane before addition of tetraethyl lead, he said.

Costs of octane increases are substantial in this range, but newly-developed catalysts and processes will help keep the price of 100-plus octane fuel at a level where those motorists who require such a fuel can afford it, the speaker predicted.

Receive Safety Award

One hundred and twenty men of The Atlantic Refining Company's Philadelphia refinery machine shop have been honored by the safety council of the Philadelphia Chamber of Commerce for their outstanding safety record of 15 continuous years of work without a disabling injury. This achievement represents more than 2,600,000 hours of safe operation during the period of January 1941, to January 1956.

Kerr-McGee Acquires Cushing Refinery

Kerr-McGee Oil Industries, Inc., has completed the purchase of a 20,000-barrel-a-day refinery at Cushing, Okla., doubling the refinery capacity owned by the Oklahoma City concern.

The Cushing refinery was bought from General American Oil Company for an undisclosed amount. Kerr-McGee had been leasing the plant for more than a year.

General American, a Dallas firm, acquired the property two years ago as part of a $27-million deal in which it bought the major part of the producing and pipelining properties of Deep Rock Oil Corporation.

General American never operated the refinery. It was leased back to Deep Rock and later to Kerr-McGee when that company acquired certain Deep Rock assets last year.

Kerr-McGee also owns refineries at Wynnewood and Cleveland, Okla. These, with the Cushing plant, give the company a total crude capacity of more than 40,000 barrels a day.

Administration Urges Anti-Pollution Law

Congress was expected to take action on an administration water-pollution bill already passed by the Senate and approved by the House Public Works Committee.

The President asked Republican congressional leaders to push for a speedy passage of the bill, since existing pollution legislation was due to expire.

The bill would give the government a stronger hand in combatting pollution of streams, and also provide for additional research into the problem of pollution.

Two Companies Elected To National Constructors

Sanderson and Porter, engineers and constructors, New York, and United Engineers and Constructors, Inc., Philadelphia, have been elected to membership in the National Constructors Association.

The National Constructors Association is an organization composed of leading engineering and building firms engaged in the design and construction of chemical plants, petroleum refineries, steel mills and power plants.

Engineering Concern Forms Subsidiary

Scientific Design Company, Inc., a New York company specializing in the design and engineering of chemical-manufacturing plants, has formed a wholly-owned subsidiary for the construction of chemical plants. The new company is named SD Plants, Inc.

Purchases Refinery

The Southland Company has acquired Delta Refining Company, which operated a 6000-barrel-a-day refinery at Memphis, Tenn. Capacity of the plant will be doubled. Southland has a refinery at Sandersville, Miss., with a capacity of 5500 barrels a day.

MEETINGS CALENDAR

JULY	
17–27	Massachusetts Institute of Technology, Special Summer Program on Recent Advances in Catalytic Polymerization, Cambridge, Mass.
18–21	Silver Bay Conference on Human Relations in Industry, Silver Bay, New York.
AUG.	
9–11	Denver Research Institute, Annual Symposium on Industrial Applications of X-Ray Analysis, Albany Hotel, Denver, Colorado.
SEPT.	
9–12	American Institute of Chemical Engineers, William Penn Hotel, Pittsburgh.
10–12	American Society of Mechanical Engineers, Fall Meeting, Cosmopolitan Hotel, Denver.
10–14	International Congress on Catalysis, Bellevue-Stratford Hotel, Philadelphia.
12–14	National Petroleum Association, Annual Meeting, Traymore Hotel, Atlantic City.
16–21	American Chemical Society, Annual Meeting, Atlantic City.
17–19	American Institute of Electrical Engineers, Annual Electrical Conference of the Petroleum Industry, Kansas City, Mo.
17–21	American Society of Mechanical Engineers, Instruments and Regulators Division and Instrument Society of America Exhibit and Joint Conference, Coliseum, New Work.
17–21	Annual Instrument-Automation Conference and Exhibit, Sponsored by the Instrument Society of America, Coliseum, New York.
20–21	Mid-Continent Oil and Gas Association, Louisiana-Arkansas Division Roosevelt Hotel, New Orleans.
20–21	Mid-Continent Oil & Gas Association, Louisiana-Arkansas Meeting, Hotel Roosevelt, New Orleans.
20–21	Western Petroleum Refiners Association, Technical Industrial Relations Meeting, Henning Hotel, Casper, Wyo.
16–22	American Society for Testing Materials, National Meeting and Apparatus Exhibit, Hotel Statler, Los Angeles.
23–26	American Society of Mechanical Engineers, Petroleum Mechanical-Engineering Conference, Conrad Hilton Hotel, Dallas.
24–28	Trade Fair of the Atomic Industry, Sponsored by the Atomic Industrial Forum, Navy Pier, Chicago.
OCT.	
1– 3	Texas Mid-Continent Oil & Gas Association Annual Meeting, Rice Hotel, Houston.
1– 5	American Institute of Electrical Engineers, Fall Generals Meeting, Morrison Hotel, Chicago.
2– 4	Chemical Industry Corrosion Conference, Sponsored by The International Nickel Company, Wrightville, Beach, N.C.
8–10	American Society of Mechanical Engineers—American Society of Lubrication Engineers, Third Lubrication Conference, Chalfonte-Haddon Hall, Atlantic City, N.J.
14–20	Oil Progress Week
18–19	Western Petroleum Refiners Association, Regional Technical-Industrial Relations Meeting, Rufus Garrett Hotel, El Dorado, Ark.
22–24	National Lubricating Grease Institute, Annual Meeting, Edgewater Beach Hotel, New York.
24–25	American Society of Mechanical Engineers—American Institute of Mining and Metallurgical Engineers, Joint Fuels Conference, Sheraton-Park Hotel, Washington, D.C.
29–30	Independent Petroleum Association of America, Annual Meeting, Statler Hotel, Dallas.
NOV.	
1– 2	Society of Automotive Engineers, National Diesel Engine, Drake Hotel, Chicago.
8– 9	Society of Automotive Engineers, National Fuels and Lubricants Meeting, Mayo Hotel, Tulsa.
12–15	American Petroleum Institute, Annual Meeting, Conrad Hilton Hotel and Palmer House, Chicago.
27–30	American Chemical Society, National Chemical Exposition, Cleveland, Ohio.

THIS IS THE STORY of three men and a VALVE. Joe, a chemical engineer, needed valves that could handle tough corrosives. Bill, a refining engineer was looking for valves that gave a positive shut-off. Tom, working for a large industrial firm, needed valves that sealed both upstream and downstream. All three solved their problems by specifying Hamer Visible Wedge Valves. These remarkable valves combine the double sealing action of precision metal-to-metal fit augmented by dependable seal rings.
The wedges are trimmed with nickel, while seats are trimmed with stainless steel to withstand the roughest corrosive conditions. The full-view wedges are handwheel operated --can't blow out or drop on a toe. The wedges pivot so no lifting is necessary.
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What's Happening . . .

. . . *Among Men* in the Industry

Naylor

Huffman

C. Calvin Naylor has been named manager of Sun Oil Company's Marcus Hook refinery, succeeding **W. T. Askew**, who is being detached from the Refining department for a special assignment.

Appointed to succeed Naylor as superintendent-refining is **Walter C. Huffman**, who has been assistant superintendent-petrochemicals at Marcus Hook since March 1954. Naylor had been superintendent-refining since early this year.

James I. Harper succeeds Huffman as assistant superintendent-petrochemicals. He has been assistant director of Sun's Research and Development department in Philadelphia for the past three years. During that time his principal activities have been in petrochemicals.

John L. Olsen, formerly in charge of Technical Economics, has been named to take Harper's place as assistant director of the Research and Development department.

Frederick A. Lang, since 1944 assistant superintendent-catalytic cracking, was named to a new position of assistant superintendent-coordination. Named to succeed Lang as assistant superintendent-catalytic cracking was **William A. Casey**, assistant to the refinery manager since early this year.

William E. Hanford, director of research for The M. W. Kellogg Company, received an honorary degree of Doctor of Science at the recent commencement of Philadelphia College of Pharmacy and Science. A graduate of the college, Dr. Hanford completed his graduate studies at the University of Illinois.

Max A. Mosesman has been promoted to research specialist in the Research and Development division, and **Tom F. Stephens** and **Irving Leibson** to senior chemical engineers in the Technical Service division at Humble Oil & Refining Company's Baytown, Texas, refinery.

Dr. Mosesman holds B. S. and M. S. degrees in chemical engineering from Texas A&M College, and a Ph.D. degree in physical chemistry from the University of California; Stephens is a chemical engineering graduate from Texas A&M, and Dr. Leibson completed his B. S. and M. S. degrees in chemical engineering at the University of Florida, receiving his D. Sc. degree at Carnegie Institute of Technology.

Jennings B. Hamblen, formerly safety director of Pan-Am Southern Corporation, has been named assistant director of safety for the American Oil Company.

Hamblen joined the research department of Standard Oil Company (Indiana), parent company of American, at the Whiting, Ind., refinery in 1927. In 1935, he was transferred to the Destrehan, La., refinery of Pan American Petroleum Company as assistant superintendent, and a year later was transferred to Amoco's Texas City, Tex., refinery as head of the Catalytic and Distillation department. In 1947, he was transferred to New Orleans as general manager of manufacturing for Pan-Am Southern, and in 1951 was named safety director for that company.

L. A. Curran, formerly general manager of refining operations for Aurora Gasoline Company, has been appointed assistant vice president of manufacturing. In that capacity, he will assist **F. C. Moriarty,** vice president in charge of manufacturing.

P. A. Blasco, who was assistant general manager of refining operations, was promoted to succeed Curran as general manager. Both will continue to headquarter in Detroit.

Hanson

Bell

John E. Bell has been appointed chief engineer in the Manufacturing department of Sinclair Refining Company. He succeeds **Thomas D. Tifft,** who is retiring after 36 years with the company.

Named to replace Bell as assistant chief engineer in the Manufacturing department was **Donald E. Hanson.** He has been part of the company's engineering staff in New York for the past year.

Bell joined Sinclair in the Research and Development department in 1934. In 1943 he was project engineer on construction of the company's Corpus Christi, Texas, refinery, and subsequently he held similar assignments.

He was placed in charge of the Central Engineering department at the East Chicago, Ind., refinery in 1949, and two years later was shifted to his most recent assignment in New York.

Hanson joined Sinclair's Research and Development department in 1942. He transferred to the Refining department in 1944 and in 1953 was named project engineer following the design and construction of Sinclair's catalytic-reforming units.

Mawhinney

Wynkoop

Robert J. Mawhinney, head of Houdry Corporation's Patent and Licensing division, has been elected to a place on the board and named vice president for patents and licensing.

Also receiving an executive appointment with Houdry was **Raymond Wynkoop,** named staff assistant to the president. His responsibilities will be chiefly with corporate affairs.

Mawhinney, before joining Houdry some time ago, was head of the Patent division of the Legal department of Atlas Powder Company. During World War II, he was in charge of the New York patent group of the Manhattan atomic energy project.

Dr. Wynkoop, who went to Houdry from International Minerals and Chemicals Corporation, previously had been with National Distillers Products Corporation as senior chemical engineer on the staff of the vice president in charge of chemical operations.

Robert O. Law has been appointed manager of a newly-created Economics department of D-X Sunray Oil Company. The department was established as part of the company's refining and marketing expansion program.

Before joining D-X Sunray, Law was economic consultant in Mexico for Stanford Research Institute. For three years, he was assistant director of the Bureau of Business Research at the University of Oklahoma.

LeRoy Culbertson has been promoted to assistant manager of Phillips Petroleum Company's Natural Gasoline department, replacing **Roy M. Teel,** who resigned to enter the consulting business.

Louis P. Sumpter was named director of the Engineering and Construction division; **H. R. Markley** was appointed to succeed Sumpter as director of the Operating division, and **O. F. Grover** was promoted to the newly-created post of director of the Service division.

Another newly-created position in the Natural Gasoline department will be filled by **W. L. Phillips,** who was made director of the new Plants and Joint Enterprises division headquarters at Bartlesville. **R. C. Mason** replaces Phillips as superintendent of the department's Western district.

Sumpter started with Phillips in 1935 in the Natural Gasoline department's West-

NEW TECHNIQUE *for* INERT ARC WELDING OF PRESSURE PIPING DEVELOPED BY STONE & WEBSTER

Stone & Webster engineers have perfected a new, improved technique for inert arc welding of pressure piping. The main feature of the process is the initial preparation of root edges. With edges properly prepared, the joint weld produces satisfactory, uniform inside bead conditions in all positions.

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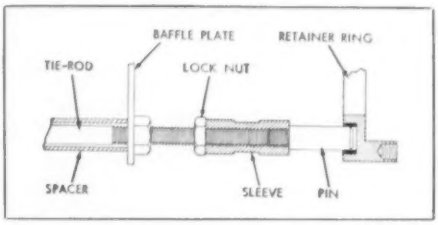

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Men in the Industry . . .

ern district. He served in several Oklahoma and Texas districts until 1947 when he was sent to Bartlesville as staff director in charge of manufacturing. Four years later he was advanced to superintendent of the Operating division.

Markley joined the company in 1932 at Burbank, Okla. He also served in Oklahoma and Texxs districts, and in 1951, he was transferred to Bartlesville as superintendent of plant operations.

Grover joined Phillips in 1934 in the Oklahoma district, and was moved to Bartlesville in 1938 to take on various engineering and supervisory assignments. Since 1945, he has been staff director of product correlation.

Phillips has been with the company since 1936. He served in various engineering and supervisory positions in Texas until 1947 when he was made assistant district superintendent for the Western district. This was followed four years later by his promotion to superintendent.

Mason, who will succeed Phillips at Odessa, Texas, joined the company in 1925 as chief engineer in what was then its Breckenridge district, served at various natural gasoline plants as superintndent, and as area supervisor at Pampa, Texas. He became assistant district superintendent of the Western district in 1951.

Andrea

Brown

W. F. Brown has been promoted to the newly-created position of assistant manager of manufacturing for Continental Oil Company's Rocky Mountain region.

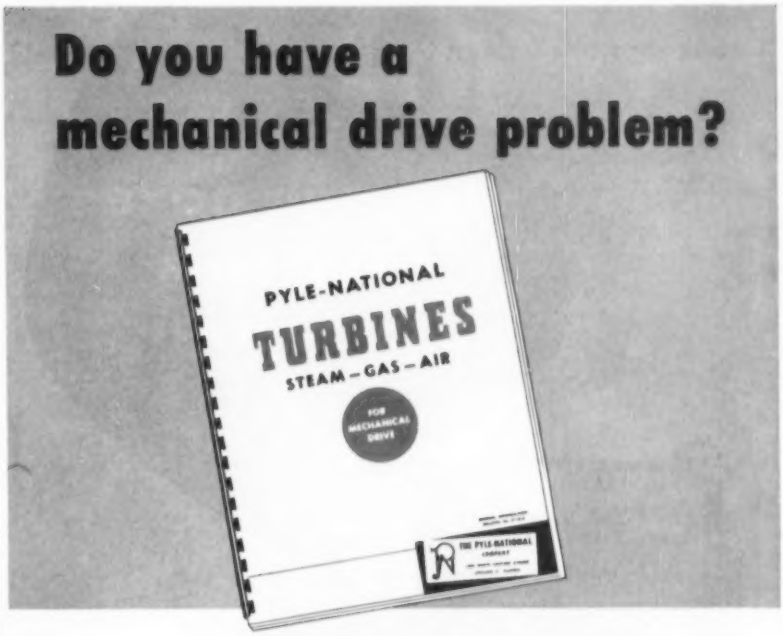
Formerly superintendent of Conoco's Lake Charles refinery, he will make his headquarters in Denver. He is succeeded at Lake Charles by **K. S. Andrea,** formerly assistant to the vice president at Ponca City.

Brown joined Conoco at Ponca City in 1943. Before becoming superintendent of the refinery at Lake Charles in 1954, he served successively as superintendent of the Lubricating Oil and Catalytic Cracking divisions at the company's Ponca City refinery.

A graduate of the University of Tulsa, he was awarded a Sloan Fellowship in 1950 and studied a year at Massachusetts Institute of Technology.

Andrea became associated with Conoco in 1941 at Ponca City. He served in various manufacturing positions at Lake Charles for eight years before he was promoted in 1949 to assistant superintendent of the company's Billings, Mont., refinery. He had been assistant to the vice president at Ponca City since 1954.

Don Kennedy has been appointed a technical associate in the Research department of Standard Oil Company (Indiana) at Whiting, Ind. Also receiving a



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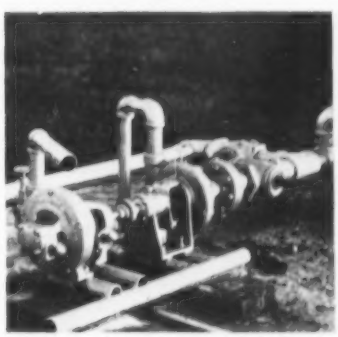

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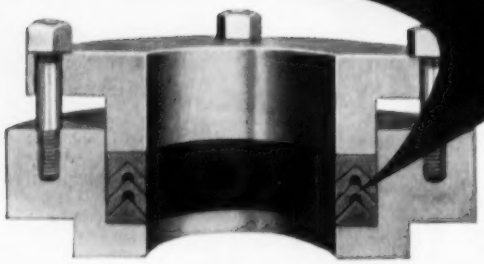

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Men in the Industry . . .

new assignment in the Research department was **William G. Stanley,** who was named a group leader and transferred to the company's laboratory at Seymour, Ind.

Kennedy joined Standard Oil's Research department at Whiting in 1954. Dr. Stanley became associated with the company's Whiting research laboratories in 1951.

George C. Caine has been named manager of the Manufacturing department of Tidewater Oil Company's Eastern division with headquarters at the company's new Refinery under construction near Wilmington, Del.

Caine formerly was general superintendent of Tidewater's Bayonne, N. J., refinery which was sold earlier this year. His assignment prior to this recent appointment involved the direction and coordination of all activities relating to the planning, design, and construction of the 130,000 barrel-per-day Delaware Refinery.

Caine

The new refinery manager joined the company in 1926 as an engineer in the Development department at Bayonne and the following year was promoted to assistant to the supervisor of the Paraffin and Lubricating department. Caine was named assistant processing superintendent in 1931; assistant general superintendent in 1938, and general superintendent in 1943.

Tidewater also has named two assistant managers for the new Delaware refinery. They are **Benjamin G. Jones** and **James McDonald.**

Jones joined Tidewater in 1929 as a chemist in the control laboratory at the company's Avon, Calif., refinery. He served as a process clerk from 1936 to 1937 when he was named a foreman.

He was promoted to superintendent of the alkylation and isomerization process operations in 1943, to superintendent of the catalytic cracking plant in 1948; superintendent of the thermal crackers in 1953, and to superintendent of cracking in 1954.

McDonald formerly worked at the company's Bayonne, N. J., refinery which was sold earlier this year. He joined Tidewater in 1940 as a junior process engineer, becoming technical assistant to the process superintendent in 1944. He was elevated to assistant process superintendent in 1947. Since 1954 he has been working on the engineering phases of the new refinery.

E. K. Beall, vice president in the Economics department of Phillips Petroleum Company has been appointed to a newly created position of vice president and petroleum consultant.

Henry C. Meiners, manager of the Los Angeles refinery of Union Oil Company of California, has been appointed process consultant for Union's Brea research center. He will be succeeded in Los Angeles by **John W. Towler,** who was manager of the company's Oleum refinery.

Dr. Meiners had been manager of the Los Angeles refinery since 1953, when he

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a guide to advanced designs in package unit and custom built steam generating equipment

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Package units range from 10,000 to 40,000 pounds of steam per hour while custom built units are obtainable in the larger capacities. Available in bent tube types and straight tube, forged steel sectional header types for solid, liquid or gaseous fuels burned singly or in combination.

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Two of three 41,000 #/hr. steam generators installed in Medical Center Steam Plant, Louisville, Ky.

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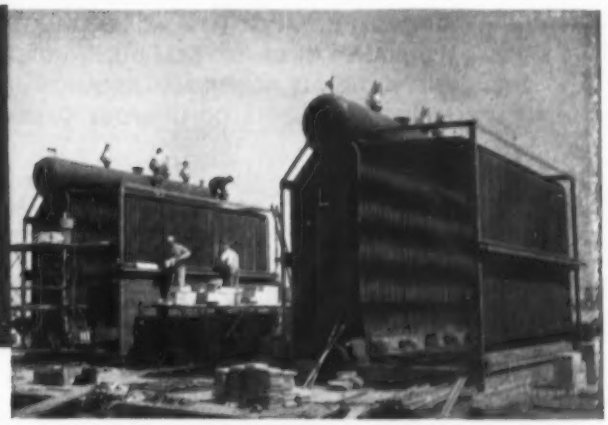

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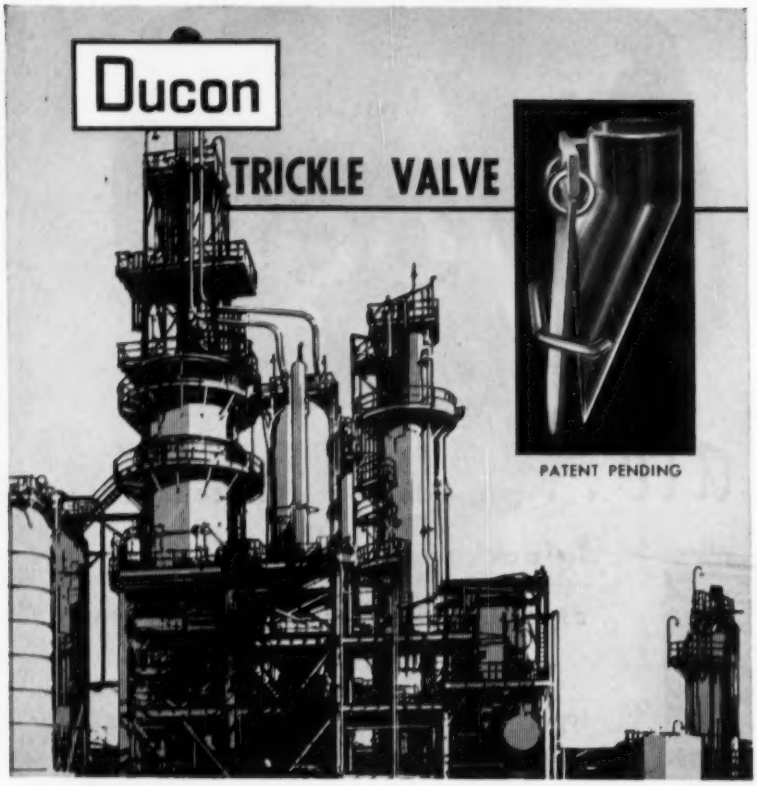

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Men in the Industry . . .

was transferred from Oleum, where he was manager. Towler served as chief engineer at Los Angeles until his appointment as manager at Oleum in 1953.

M. S. Thomson, general superintendent of operations and assistant superintendent of the Oleum refinery since 1953, becomes manager there.

Harry A. Brown, who was with Frontier Oil Company, has joined D-X Sunray Oil Company as vice president in charge of refining. He will be in charge of the company's refinery operations in Tulsa and at Duncan, Okla.

D-X Sunray's new executive was vice president in charge of manufacturing for Frontier. He also was vice president in charge of an affiliated pipe line.

Brown joined Frontier in 1946 as superintendent of refining. Before that he served several oil and refining companies in various capacities as chief engineer and superintendent.

A. E. New has been appointed as director of the Technical department in the Manufacturing division of Escambia Bay Chemical Corporation. He has been director of process development at the Texas City plant of Carbide and Carbon Chemicals Company for a number of years.

New

With Escambia Bay, New will serve the company's new plant at Pensacola, Fla. He will be responsible for process design and engineering projects starting with pilot-plant data through full plant-scale operation. He also will provide technical service to the operation of the new Florida plants and correlate the activities of the Manufacturing division with the Research division and commercial chemical development.

F. O. Koontz, a director and former vice president of Quaker State Oil Refining Corporation, has been appointed executive vice president. He has been with Quaker State 28 years.

William K. Warren, chairman and chief executive officer of Warren Petroleum Corporation, has been elected to the board of Gulf Oil Corporation. He left the Gulf organization in 1916, to found Warren Petroleum. It recently merged with Gulf.

Simon Miron has been promoted to research associate in the Research and Development department of American Oil Company at Texas City, Texas. Also receiving a promotion in the company's research organization was **R. L. Aiken,** named senior chemist.

Dr. Miron formerly was a research chemist in the Analytical division, while Aiken has served in the department's Methods Development section. Aiken will continue to serve as group leader, a position he has held with the company since 1953.

A graduate of Rice Institute and holder of a Ph.D. degree from the University of Pittsburgh, Dr. Miron joined Amoco

For more data on advertised products, use Readers' Service Cards, last page.

Men in the Industry . . .

in 1946. Aiken, who is a chemistry graduate of the University of Pittsburgh, joined the company in 1942.

Another new assignment in American Oil Company's Research and Development department at Texas City went to **L. W. Hamilton,** named a group leader in the Process Development section.

Hamilton joined the company in 1951, following his graduation from Vanderbilt University. He has spent all his time in the Process and Development section, except for a brief tenure in the Economics section of the Research and Development department.

Wilson K. Minor has been elected comptroller of Standard Oil Company of California. Assistant comptroller since 1947 and a member of the Standard of California organization since 1924, he was named to succeed the late **G. F. Gephart.**

W. Roberts Wood has been elected president of The Girdler Company. He succeeds **George O. Boomer,** who retired as Girdler's operating head. Boomer will continue as chairman of the executive committee of the parent National Cylinder Gas Company.

Wood

Wood was with the E. I. du Pont deNemours & Company at Newark, before joining Girdler in 1929. In 1939 he was made manager of the Gas Process division. He was elected vice president in 1941 and executive vice president in 1948. In 1953 he became a vice president and director of National Cylinder Gas.

Robert U. Haslanger has been appointed president of Escambia Bay Chemical Corporation. He succeeds **Kenneth G. Donald** who resigned to devote full time to his duties as vice president and treasurer of National Research Corporation.

Also receiving a promotion in the Escambia Bay organization was **N. C. Robertson,** director of research and now a vice president of the company.

Haslanger joined the concern earlier this year as vice president and general manager. Before joining the company, Dr. Robertson headed the Petrochemicals department of National Research Corporation.

Philip A. Kahle, Jr., has been named general manager of refining for Frontier Refining Company. He was a vice president of The Refinery Engineering Company when he accepted the post with Frontier at Cheyenne, Wyo.

Kahle joined Treco as a project engineer in 1950 and became a vice president three years later. Previously, he had been with a number of refining companies.

He served early with Eastern States Petroleum Company and later with Delta Refining Company, as chief engineer at its Memphis, Tenn., refinery. He then served as a shift foreman with Creole Petroleum Corporation in Venezuela. He returned to the U. S. as manager of refining for Eastern States in Houston, serving with that company from 1947 until he joined Treco.

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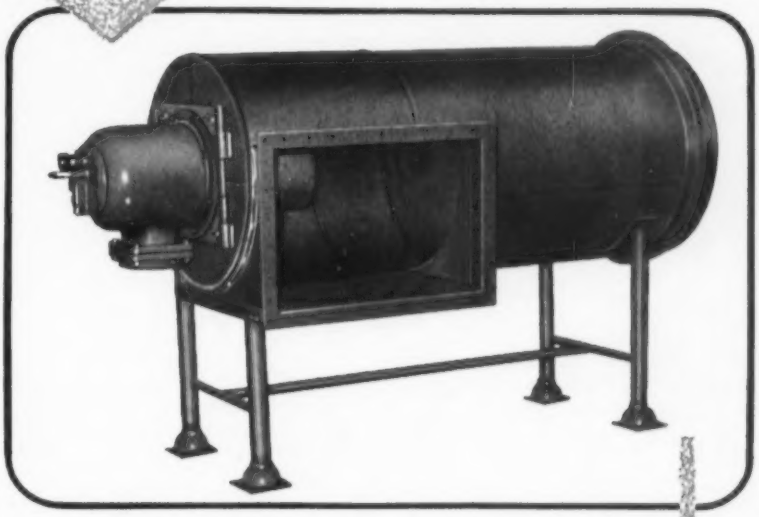

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NO REFRACTORY REQUIRED . . .

The THERMAL High Velocity Burner built into the heater permits combustion to be substantially completed within the burner itself. Thus the heater is basically a mixing chamber wherein the products of combustion are mixed with the air being heated. Refractory is not normally used. Successful applications have been made ranging from under 200,000 BTU/hr. to over 20,000,000 BTU/hr. and at all pressure levels.

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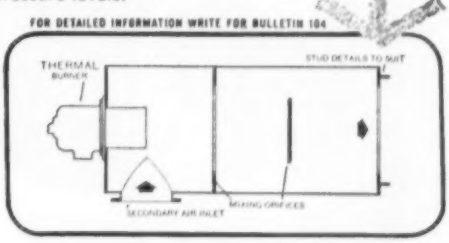
Initial cost and upkeep is kept at a minimum through the use of all welded, all metal construction. The CA Air Heaters are normally supplied as complete "package" installations.



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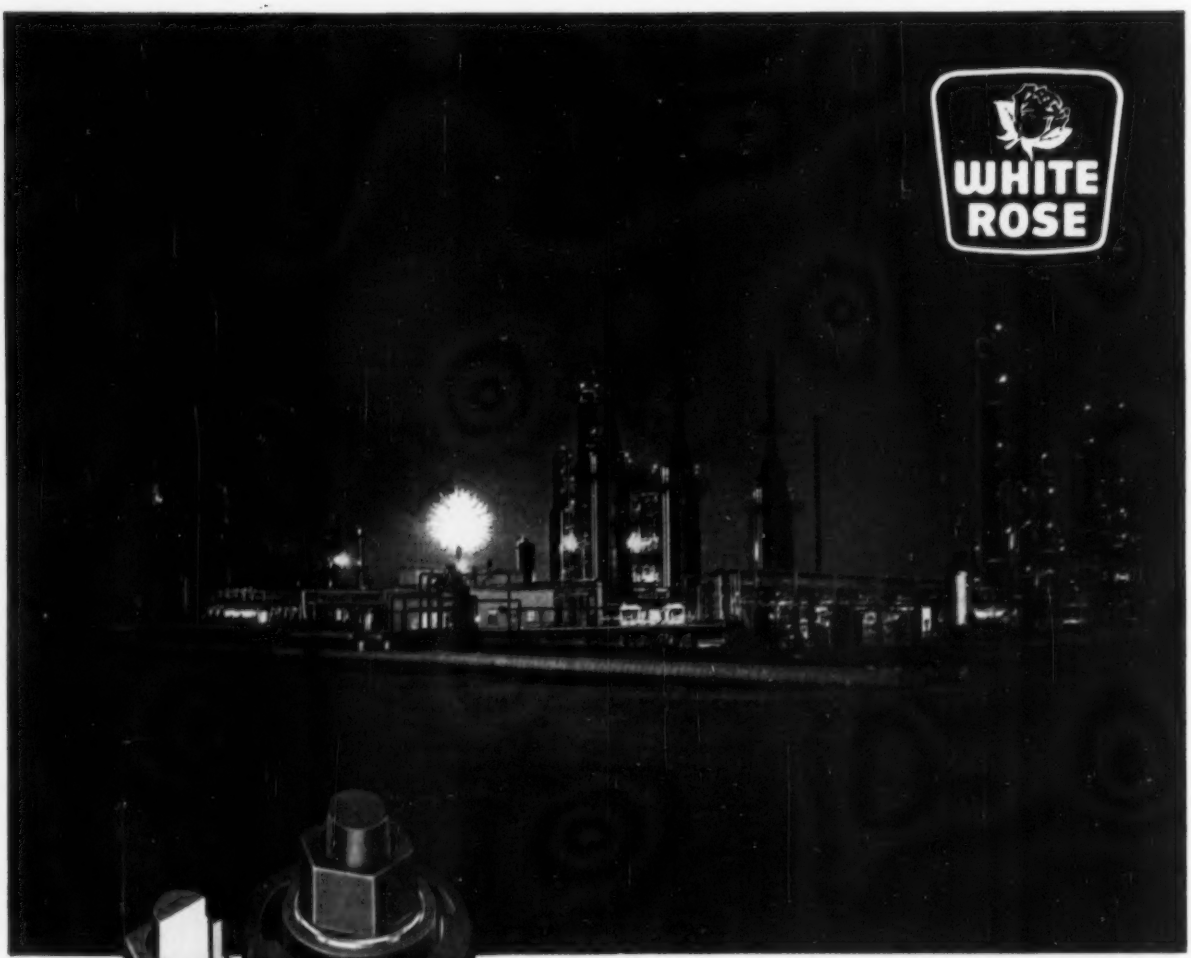

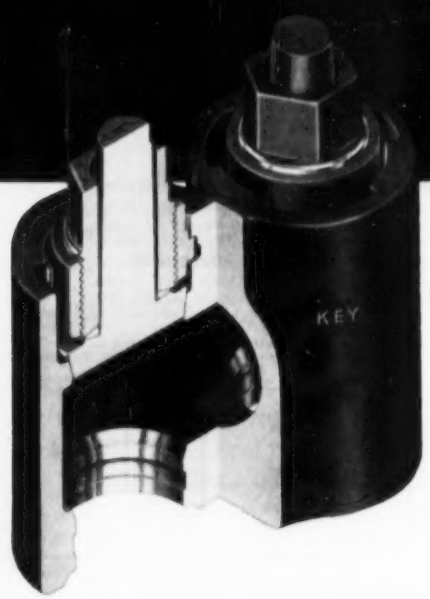

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What Suppliers Are Doing . . .

Moat

Donald E. Moat has been named director of marketing for **Leeds & Northrup Company.** Moat became assistant director of marketing and member of the Executive Operating committee last year; he had previously been manager of the company's Cleveland office. He joined L&N in 1925.

C. T. Patten has been appointed district manager of the new **Welex Jet Service, Inc.**, office in Houma, La. Patten was with the company six years, serving as a rigger, shooter, sales engineer and assistant district manager before his promotion to his present position.

Patten

James B. Hickey has been made Sales Engineer of the Washington, D. C., office of **Clark Bros. Company.** The company is a member of Dresser Industries, Inc. Prior to joining Clark, Mr. Hickey has been associated for four years with a leading manufacturer of heavy duty compressors. He was also actively engaged for a period of six years with a firm specializing in pumping and automation equipment. He replaces **William E. Dobbins,** recently named Central Regional sales manager for Clark.

L. N. Duryea has been named as resident counsel and assistant secretary of **Beckman Instruments, Inc.** His duties will relate chiefly to legal and patent matters of a corporate nature. Duryea joined the company after four years with a San Francisco law firm.

Hickey

John W. Pike has been appointed Eastern district manager of **Struthers Wells Corporation.** Previously a sales engineer in the Eastern district, he will continue to maintain headquarters in New York. Mr. Pike has been associated with Struthers Wells in various design and sales positions since 1951.

Maxwell D. Millard, who started his steel sales career as a technical apprentice with American Steel & Wire division in 1934, has been appointed general manager of sales for this division of **U. S. Steel Corporation.** Millard goes to his new post from the Pittsburgh headquarters of U. S. Steel where he has been director of distribution and availability in the Commercial department.

Duryea

Loren O. Bass has been appointed as sales office manager of **Jones & Laughlin Supply Division's** Chicago sales office. Bass has been with the company since 1950, when he was assigned to a storeman at Perry, Okla. In 1953, he was transferred to Chicago as a salesman and served in this capacity until his recent advancement.

Pike

Charles D. Branson has been made assistant director of research of **Robertshaw-Fulton Controls Company.** He will make his office at the company's eastern research facility at Irwin, Penn. Branson has been with the organization for more than 20 years. Formerly he was chief engineer at the company's Fulton Sylphom Division at Knoxville, Tenn. He has also held the positions of assistant chief engineer, development engineer and laboratory assistant, and for a time was engaged in production and inspection work.

Seth M. Snyder has been appointed manager of the Charlotte, N. C., district sales office of **The Babcock & Wilcox Company's** Boiler division. At the same time, the company's Charlotte sub-office was elevated to full district office status. Snyder joined B&W as a draftsman in Barberton, Ohio, in 1936. Subsequently he worked in production, studied under the company's engineering apprentice program, and gained experience in the erection, service and contractual phases of the boiler business. In 1939, he joined the company's Atlanta, Ga., sales organization, and moved to the Charlotte sub-office in 1946.

George L. Leupold has been appointed assistant general sales manager of the Fulton Sylphon division of **Robertshaw-Fulton Controls Company.** He will make his office at division headquarters at Knoxville, Tenn. Leupold joined the company in 1946 as district manager of the Cincinnati office. He has had more than 20 years experience in the controls field. Prior to that he was employed for five years in the chief engineer's office of Illinois Bell Telephone Company.

Millard

Bass

Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation has made eight reassignments in its sales organization.

L. R. Bingaman is assigned to the Philadelphia district. He graduated from Susquehanna University in 1955 with a B.A. in chemistry.

J. R. Conaway will now work in the St. Louis district. He came with the company in 1955 after graduating from Duke University with a B.S. in chemistry.

J. T. Ferguson is transferred to the New York district. He graduated from Rensselaer Polytechnic Institute in 1955 with a B.S. in biology.

M. M. Maupin is transferred to the Houston district. A graduate of the University of Nebraska with a B.S. in chemical engineering, he joined the company in 1955.

A. Pros is assigned to the New York district. He joined the company in 1945 after graduating from Brooklyn Polytechnic Institute with a B.S. in chemistry.

R. A. Schongar will now work in the Newark district. He came with the company in 1954 after graduating from Colgate University with a B.A. in chemistry.

D. P. Shannon is assigned to the Chicago district. He graduated from Fordham University in 1952 with a B.S. in chemistry and joined the company in 1954.

R. S. Trebus is transferred to the Kansas City district. He graduated from Duke University in 1954 with a B.A. in chemistry and joined the company in 1955.

Branson

Tube Turns, division of National Cylinder Gas Company, has elected **John G. Seiler** as president. He succeeds **George O. Boomer,** who is retiring. Boomer will continue as chairman of the executive committee of National Cylinder Gas Company.

Seiler joined Tube Turns in 1930. A year later he was appointed sales manager. He was made vice president at the

Snyder

Leupold

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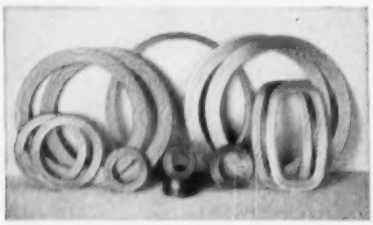

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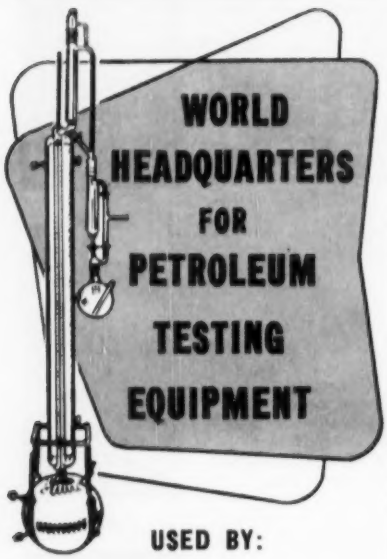

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Suppliers . . .

beginning of World War II, and general sales manager in 1945. He was elected a vice president of National Cylinder Gas Company at the same time he was elevated to the presidency of Tube Turns.

Crane Company and Republic Steel Corporation have become equal partners in Cramet, Inc. a producer of titanium sponge. Cramet was a wholly-owned subsidiary of Crane.

Cramet will remain a separate corporation. A new board of directors, consisting of four representatives of each of the parent companies, has been organized. Members are:

Frank F. Elliott, president of Crane Company; **John P. Magos**, director of engineering, Crane; **Paul L. Yates**, comptroller, Crane; **Earl E. Wyatt**, Crane executive assistant; **C. M. White**, president of Republic Steel Corp.; **T. F. Patton**, Republic assistant president and first vice president; **Norman W. Foy**, vice president in charge of sales, for Republic, and **E. R. Johnson**, vice president in charge of operations, with Republic.

Cramet, formed by Crane Company in 1953, has constructed a plant at Chattanooga, Tenn., which will have a capacity of 6000 tons of titanium sponge annually. The plant was built under a contract with the General Services Administration. Under this contract, the government has advanced $24,950,000 toward the construction of the plant.

The Mercoid Corporation has elected **W. K. Stauffer**, who was manager in charge of its Philadelphia Branch, to vice president of the Eastern area.

R. F. Fischer, the vice president who was in charge of the Eastern area, was transferred to Los Angeles where he will supervise the sales activities of the West Coast area.

John Shedden was appointed manager of the New York branch, and **F. W. Ayer** was named to replace Stauffer as manager of the Philadelphia branch.

Wolverine Tube, division of Calumet & Hecla, Inc., has named **Sam Robb** to a position in its General Sales office in Detroit. Formerly a Wolverine sales representative in the New York area, Robb has been with the company 22 years.

The International Nickel Company, Inc., has appointed W. A. Mudge as special representative on Educational programs for it and its affiliate, The International Nickel Company of Canada, Ltd.

This newly-created post in the office of the president is an extension of International Nickel's educational program.

Dr. Mudge will relinquish his duties as director of the Technical Service section of the Development and Research division, a position which he has held since 1947. During this time he has also been identified with educational activities carried on by Inco. These include a program of co-operation with universities and colleges in Canada, the United Kingdom and the U. S. in the dissemination of technical information as well as the granting of fellowships and scholarships.

Dr. Mudge joined International Nickel in 1920 as a member of the Research department at the company's Bayonne works in New Jersey.

American Meter Company, Inc., has appointed **Richard E. Martin** to the position of sales-engineer for the Pittsburgh sales district. Martin will make his headquarters at Lexington, Ky.

Martin joined American Meter in August 1955. He was formerly general superintendent of Gas and Water Utilities, Morehead, Ky., for 5 years and previously was associated for nine years with Chester Engineers in Pittsburgh.

U. S. Steel Corporation has appointed **E. J. Lacombe** as manager of sales in the New Orleans sales office of Na-

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GOV'T. METHOD 3703 and ASTM D-1319 F.I.A.
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ULTRA - VIOLET Model X-40 . . . single tube, 3650 Angstrom units, length 49" overall, 40 watt. For 110 volts A.C.

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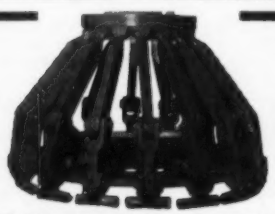

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Suppliers . . .

tional Tube division. He had been assistant manager of sales. He succeeds **T. W. Thorne** who has retired.

Lacombe joined U. S. Steel Corporation in 1927 and has spent most of his time in the New Orleans and Dallas areas.

In 1951, however, he was transferred to the division's main office in Pittsburgh, where he served until 1954 in an administrative capacity in the sales department before being transferred back to New Orleans.

Beckman Instruments, Inc., has established a new Analog Computer department of its Beckman division. The department will be headed by **Joseph L. Hussey**, formerly chief engineer for computers.

The new department is responsible for sales, installation, field engineering and design and development of special computer equipment.

A member of the Beckman organization nearly four years, Hussey was associated with Northrop Aviation Company, as a member of the computer facility devoted to guided missile development. He was graduated from the University of California at Los Angeles with a degree in physics.

Hussey's former research and devlopment duties at Berkeley will be assumed by **Alan MacLane.**

Wolverine Tube, division of Calumet & Hecla, Inc., has presented its Diamond Key Award to **D. J. Missimer,** with Pacific Refrigeration Company in Los Angeles.

Awarded annually since 1940 for outstanding technical papers in the refrigeration field, the 1956 Wolverine Diamond Key was bestowed upon Missimer for his article "Cascade Refrigeration Systems for Ultra-Low Temperatures."

The award presentation was made at the annual meeting of the American Society of Refrigeration Engineers in Cincinnati.

Koppers Company has acquired a 285-acre tract at Arroyo, W. Va., as the site for a dual-purpose facility of its Tar Products division.

This facility will consist of a processing plant for the manufacture of nicotinic acid and a development plant in which work will be done toward the continued upgrading of coal-tar chemicals. Both plants will be designed to allow for anticipated expansion in the tar-chemicals field, but the initial construction will utilize only a small portion of the 285 acres. Ultimately, the company expects to spend several million dollars in plant construction at the site.

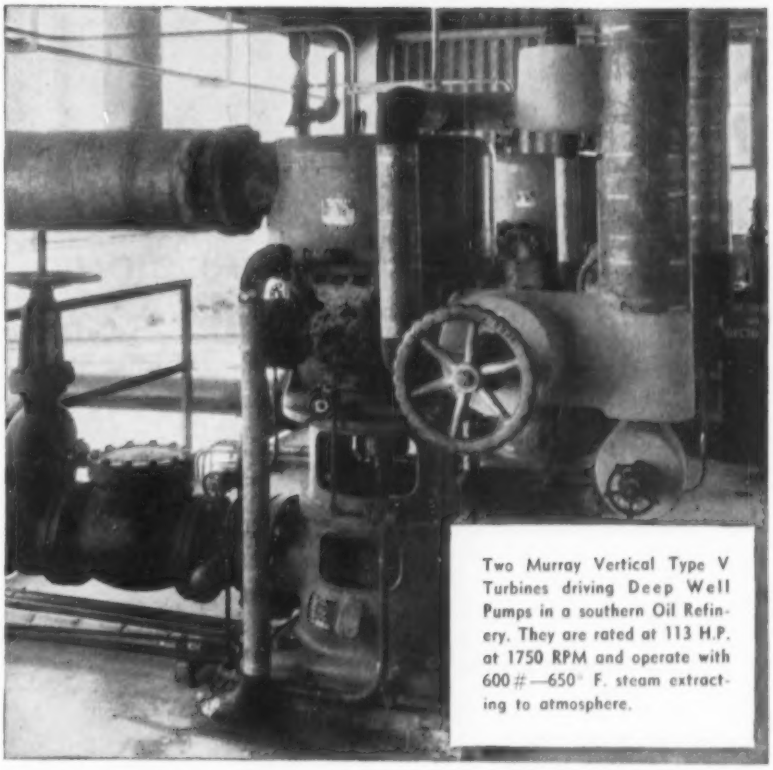
Koppers Engineering and Construction division designed the new plant and laboratory buildings, and construction has been started. Completion of the plants is expected early in 1957.

Fischer & Porter Company has made two new appointments of representatives for its International division in South America. They are:

S.A.V.E.R. Guinand, representatives for industrial instrumentation and chlorination equipment in Venezuela.

Tecnica Colombiana, S.A., representatives for chlorination equipment in Colombia.

Murray Turbines



Two Murray Vertical Type V Turbines driving Deep Well Pumps in a southern Oil Refinery. They are rated at 113 H.P. at 1750 RPM and operate with 600#—650° F. steam extracting to atmosphere.

• Murray Vertical V turbines, both geared and direct-connected, are being used more and more for driving vertical pumps of all types. The Murray Vertical V turbine is designed from top to bottom as a vertical turbine, not just a horizontal turbine, "upended." The Murray Vertical is especially constructed and arranged for vertical mounting.

Murray vertical turbines can be furnished for steam pressures up to 600#, 750° F. TT. and back pressures as high as 100# and can carry most normal thrust loads imposed by vertical pumps.

MURRAY IRON WORKS COMPANY

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Builders of Steam Power Equipment for Three Quarters of a Century

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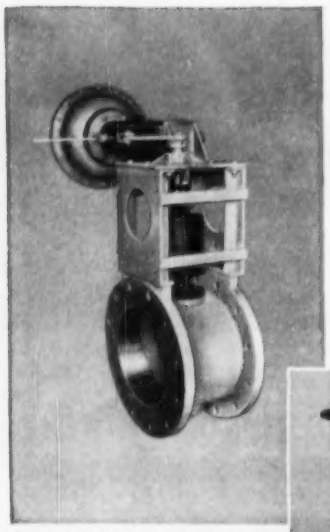
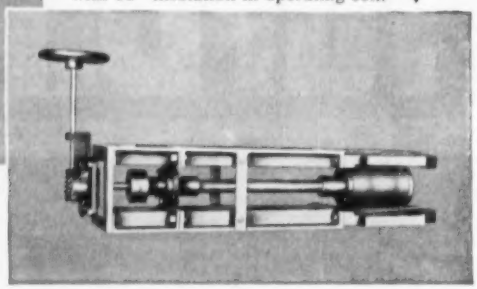


R-S
BUTTERFLY VALVES

All-bronze, 150-pound R-S Valve for operation at −300° F. Valve is installed with 18" insulation in operating cell. ▼



Special 12-inch R-S Butterfly ▲ Valve, with finned lubricated stuffing box, is used for service with hot gases at 1,000° F.

SPECIAL R-S VALVES SOLVE TEMPERATURE, CORROSION, ABRASION PROBLEMS

To meet rugged processing conditions, R-S Butterfly Valves can be built to your requirements. For valve bodies and parts, any metal or other material that can be cast or welded — even plastics — may be specified.

There are a number of materials available to meet extreme working conditions involving corrosion, abrasion, erosion, high heat and pressure. In addition, the R-S Rubber-lined Valve may be specified to resist certain types of corrosion. Every R-S Valve gives you quick and positive closure with any type of controls, uniform control in normal regulating ranges and minimum pressure drop.

If your past experience offers no precedent, you can call on our background in specialized valve engineering to solve material problems.

We have built valves to operate in a temperature range of from −300° F to +2,000° F. For complete information on our complete line of butterfly, ball and cone valves, see our local representative or write S. Morgan Smith Company, York, Pennsylvania.

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Suppliers . . .

Koppers Company, Inc., has purchased a 176-acre tract of land near Monroeville, Pa., as the site for a new multi-million-dollar research center.

Koppers expects that the scope of its research program will be tripled within the next ten years. In this program which the company plans to carry out at the new Monroeville site the necessary research facilities will be provided to take care of its needs for several years.

At present, the majority of Koppers research work is being carried on at the company's Verona, Pa., research center. There, the company has modern facilities but is limited in its expansion program because additional land is not available.

Norton Company has received the first New England presentation of the Department of Defense Reserve Award. The award was presented by Rear Admiral John A. Snackenberg, commandant of the First Naval district.

This recently-authorized award was established to honor companies with policies regarding employe-reservists which serve to encourage participation in reserve activities.

Stauffer Chemical Company has appointed **E. William Eipper** to the position of director of the Market Development department. A graduate of Stanford University, Eipper joined Stauffer in 1954 as western manager of market development. He will continue to headquarter at the company's San Francisco office.

Olin Mathieson Chemical Corporation has selected **Phillip C. Brownell** as general manager of the Ecusta Paper division of its wholly-owned subsidiary, Ecusta Paper Corporation.

He replaces **Lawrence F. Dixon,** a vice president of the paper company, who is retiring as general manager of the division.

Brownell, who also is a vice president of Ecusta Paper Corporation, joined the company in 1947 as counsel. He has been associated with executive activities of the company and has most recently been an assistant general manager of the paper division.

Before joining Ecusta he was general counsel for the War Labor Board and the National Wage Stabilization Board and had previously served with several other government agencies in Washington and practiced law in New York City.

The M. W. Kellogg Company has located the Chicago sales offices for two of its divisions at 221 North LaSalle Street. They are the Chemical Manufacturing and the Chimney divisions. They were headquartered at 79 East Adams.

U. S. Steel Corporation has appointed two new store managers, two field representatives and a district representative, all in its Oil Well Supply division.

Named as district representative for Oilwell in New Orleans was **James T. Love.** He was transferred to New Orleans from Beaumont, where he was district engineer.

Love joined the company in 1946 at Beaumont as district engineer in refinery and pipe-line sales. In 1950 he was made store manager at Beaumont, and in 1953

Suppliers . . .

he became district engineer, the position he held prior to his new assignment.

The two new field representatives are **Johnie George Thomas,** formerly assigned to the store at Odessa, Texas, and now with the division at Hobbs, New Mexico, and **Roy A. Johnston, Jr.,** who was transferred to Shreveport, La., from El Dorado, Ark.

Thomas was employed by Oilwell at Odessa in 1952 and was transferred to McCamey, Texas, in 1953. Later that year he left the division for service in the Army, returning in 1953 to the Odessa store.

Johnston started with the company at Shreveport in 1952. In 1955 he was appointed field representative and transferred to El Dorado.

Gerald E. Miller is the new store manager at Eldorado, Kansas, and **Russell R. Runyon** is manager of the Liberal, Kansas, store.

Miller joined Oilwell in 1949 at Ellinwood, Kansas. In 1952 he was transferred to McPherson, Kansas, and in 1953 to Arkansas City, Kansas, he was until his recent assignment as store manager at Eldorado.

Runyon started with U. S. Steel at Eldorado and became store manager there in 1953. It was from there that he was transferred to Liberal.

Chicago Bridge & Iron Company has elected **R. F. Hendren,** who is its manager of plants, to be vice president of the company. A graduate of the University of Kansas, Hendren has been with the company since 1923. He has been a director since 1946 and manager of plants since 1947.

Wolverine Tube, division of Calumet & Hecla, Inc., has appointed **W. J. McGonigle** as its sales representative in the New York area. He will be replacing **Sam Robb,** who was transferred to Detroit.

Formerly with Downs-Smith Brass & Copper Company of New York, McGonigle will headquarter in New York.

Crane Company has a new director of branches. He is **Robert E. Penney,** a 31-year veteran of the company's Branch and General Office staff. He succeeds the late **Jess A. McMurry.**

Penney joined Crane in 1925 at its Los Angeles branch. He has been manager of the company's branches at Phoenix, Ariz.; Jacksonville, Fla., and Los Angeles.

He served as western district manager with headquarters at Los Angeles before being named executive assistant at the firm's general office in Chicago last year.

Minneapolis-Honeywell Regulator Company has appointed a new vice president. He is **Glenn E. Seidel,** who will be in charge of engineering.

Seidel has been a member of Honeywell's engineering organization nearly 14 years and since 1952 has been vice-president in charge of engineering in the firm's Minneapolis plants.

In his new position, he will have responsibility at the top-management level for coordinating and directing research and engineering activities throughout the corporation, and will represent these activities in corporate plans and decisions.

Such activities range from basic research work at the Honeywell Research Center in

TC
TENNESSEE CORPORATION
LIQUID SULFUR DIOXIDE
HIGHEST QUALITY
SO2
A SOLVENT
of ECONOMY and EFFECTIVENESS!
Tennessee's Liquid Sulfur Dioxide, a product of highest purity, is particularly suitable as a solvent for recovery of aromatics—It is completely miscible with aromatic hydrocarbons over a wide temperature range, while the solubility of naphthene and paraffin hydrocarbons is limited and increases with decreasing temperature. Recovery of a higher percentage of aromatics is obtained for hydrocarbons over a wide boiling range.
Perhaps Tennessee's highest purity Liquid Sulfur Dioxide can effect a more efficient and economical operation in your processing. We would like to discuss these possibilities with you.
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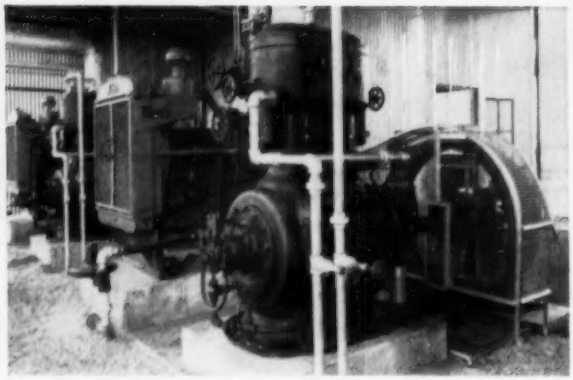
TENNESSEE TC CORPORATION
617-629 Grant Building, Atlanta, Georgia

How to Cool 5,000,000 cu. ft. of Natural gas most economically



Woodward & Company are doing it at their plant near Washington, Oklahoma, with two Frick refrigerating machines driven by natural gas engines of 90 horsepower. These Frick compressors, which handle ammonia, are of size 9″ by 9″, and run at 400 r.p.m.

Propane and gasoline are recovered from the natural gas stream. A Frick condenser is used after the propane has been fractionated. The cooling equipment was installed by the Kay Engineering Company, Frick Distributors in Oklahoma City.

Whether you need cooling equipment for air conditioning, process work, ice making, quick freezing or other refrigerating purposes, you get the utmost economy and reliability when you insist upon Frick equipment. Write today for literature and estimates on the cooling work you wish to do.

DEPENDABLE REFRIGERATION SINCE 1882

FRICK CO.

WAYNESBORO, PENNA. U.S.A.

install J.H.H. VOSS VALVES in your compressors for peak performance

(AIR • GAS • AMMONIA)

Our detailed proposal for increasing efficiency of your compressor will be sent without obligation. Send name, bore, stroke, and speed of machine.

Peak performance, maximum efficiency, greater output, and lower power costs can be built into your oldest, and of course your newest, compressors by the installation of VOSS VALVES.

Check THESE VOSS VALVE ADVANTAGES:

- Quiet, vibration-free operation
- 20 to 60% more valve area
- less power consumption
- minimum pressure loss
- utmost safety
- normal discharge temperature
- lower operating costs

J.H.H. VOSS VALVES REG. U.S. PAT. OFF.

J. H. H. VOSS CO., INC.
785 East 144th St., N. Y. 54, N. Y.

Suppliers . . .

Hopkins to applied research and a wide variety of engineering carried on in the company's manufacturing divisions scattered throughout the U. S. Of Honeywell's 27,000 employes, better than one out of every 10 is engaged in research or engineering activities.

Seidel has served in a number of administrative posts since joining Honeywell in 1943. He was successively field engineer, engineering supervisor, manager of development engineering, and before becoming vice president, he was director of the company's ordnance division which supplies precision controls and weapons systems for tanks and other military vehicles.

Rheem Manufacturing Company has appointed **William R. Dickinson** as its resident representative for drums and pails. The appointment represents a new expansion of the company's activities in Kansas, Iowa, Nebraska and South Dakota.

Dickinson will locate in Kansas City. Formerly in Chicago with the company's Container division, he has been in the industrial-packaging business since his graduation from Northwestern University.

Celanese Corporation of America has moved its European office from Dusseldorf, Germany, to Geneva, Switzerland. R. J. Davis will be in charge of the office.

M. B. Skinner Company has begun work on a new building that will increase present floor space by more than 30 percent. Besides providing expanded production facilities, the new building will house a new and complete testing and development laboratory with adjacent engineering offices.

Rhodia, Inc., has appointed Comerciale Reka S. A. as sales and technical representative for synthetic aromatic chemicals and compounds in Mexico, with offices in Mexico City. Also announced was the appointment of **Luis Felipe,** Havana, as sales and technical representative for the company's products in Cuba.

Dresser Industries, Inc., has formed a French subsidiary, Societe Francaise des Industries Dresser, S. A. This new French corporation will represent several of Dresser industries in France, and provide technical services to the Dresser companies operating on the continent.

Raymond Chesneaux, formerly assistant manager of Dresser, A. G., Paris and long active as a representative of Dresser companies abroad, has been named president of the newly formed corporation which will headquarter in Paris.

Graver Water Conditioning Company has opened a new sales-service office in Boston to service the New England area. **William A. Homer** will be district manager in charge of the office.

Homer has been with Graver since 1952 in the Customer Service department and the Sales Engineering department.

General American Transportation Corporation has transferred **Norman Wiseman** from its San Francisco office to the sales organization of the Plate and

For more data on advertised products, use Readers' Service Cards, last page.

WATER TREATMENT

PURIFICATION • CONDITIONING
RECLAMATION

Call the nearest DROKE representative.

He has the COMPLETE LINE of equipment and processes for handling your water treatment problems.

Make your plant more efficient and profitable.

J. W. DROKE & ASSOCIATES

TULSA	FORT WORTH	HOUSTON
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Now—a complete and integrated treatment of unit operations in MASS TRANSFER

HERE is an introduction to the general features of diffusion and the techniques used in the industrial applications of the mass-transfer operations. Not only does the book give you a sound background in theoretical material, but also covers the principles of equipment design, equipment operation, and fields of application for a number of unit processes. Humidification and dehumidification, gas absorption, distillation, liquid extraction, adsorption of liquids and gases, ion exchange, drying, leaching, and other unit operations are all discussed. In addition, many of these unit operations are treated in a unique fashion.

MASS-TRANSFER OPERATIONS

By ROBERT E. TREYBAL

666 pages, 6 x 9, 348 illustrations, $9.50

This book presents an integrated treatment of unit operations. The entire discussion for any one operation is contained in one chapter for both stagewise and continuous-contact equipment and methods. A generalized method of design is developed progressively throughout the book, with the principles of diffusion thoroughly reviewed and basic concepts common to all the operations explained in practical terms.

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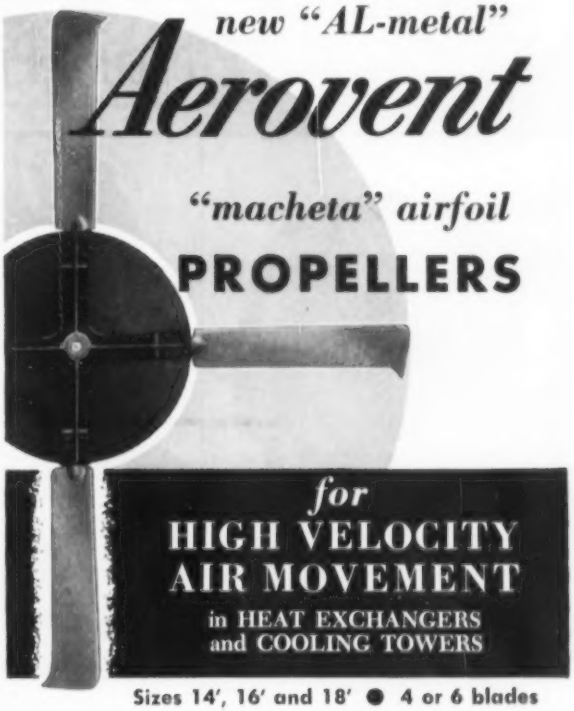
for top performance

new "AL-metal"

Aerovent

"macheta" airfoil

PROPELLERS



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HIGH VELOCITY AIR MOVEMENT
in HEAT EXCHANGERS and COOLING TOWERS

Sizes 14', 16' and 18' ● 4 or 6 blades

New Aerovent "AL-metal" Propellers for Cooling Towers, Heat Exchangers and special commercial and industrial applications, feature a new modification of the famous "Macheta" Airfoil Propeller – regarded for years as *industry's most efficient air-moving surface!*

Accurately-balanced, cast aluminum blades, designed to move *more* air with *lower* power consumption, are interchangeable with other blades in each assembly to speed and simplify installation and routine maintenance.

High-strength, cast steel alloy hubs, employing bolted construction, clamp keyed blade shanks securely to prevent loosening or turning; provide maximum resistance to vibration and operating stresses.

designed for
DEPENDABLE
operation

Endurance tests at 3 *times* normal loading prove the ability of new Aerovent "AL-metal" Propellers to withstand punishment far in excess of operating requirements.

Other models for any type installation

Write today for free folder, engineering assistance and/or detailed performance data

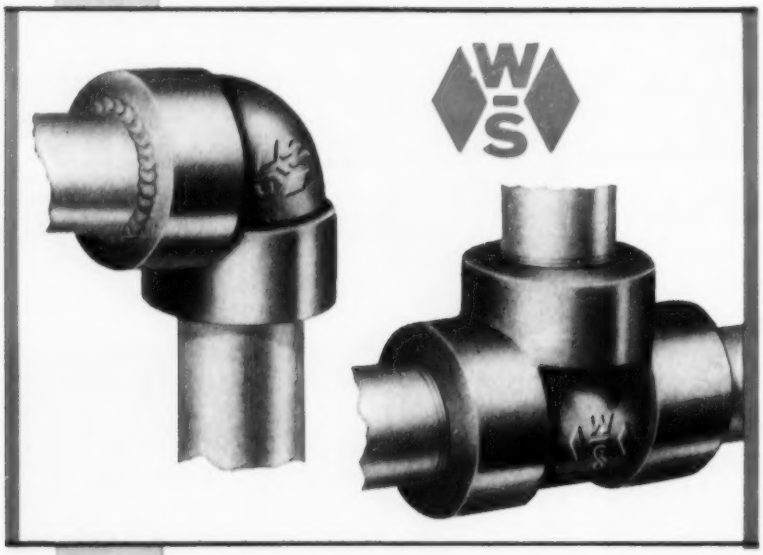
Aerovent FAN COMPANY, INC.
LARGE PROPELLER DIVISION

304 Wright Bldg.
TULSA 3, OKLA.

Main Office and Factory
PIQUA, OHIO

For more data on advertised products, use Readers' Service Cards, last page.

2 Safe Ways to PROTECT Pressure Piping...



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Pipe joints are potential trouble spots in high pressure piping systems. Change in direction of flow causes turbulence, erosion and vibration. Watson-Stillman fittings are made to absorb this type of punishment. They're drop-forged for strength and toughness and safety-factor designed for the protection of your piping.

Choose between a welded piping system and a screwed one to suit your needs. Then choose W-S Screw-End or Socket-Welding Fittings to join your pipe. They're available in sizes ⅛" to 4" for piping up to 6000 lb. W.O.G. class. For high temperature or corrosive service you can get W-S Forged Stainless and Alloy Steel Fittings, too. Send today for our informative catalogs.

W-S FITTINGS DIVISION

H. K. PORTER COMPANY, INC.
Roselle, New Jersey

Suppliers . . .

Welding division, with offices in New York.

Wiseman has been with General American for eight years in estimating, engineering, and erection work.

Laclede-Christy Company, Division of H. K. Porter Company, Inc., is installing a quality-control clay-testing laboratory in Fulto, Mo., which will run tests for shrinkage, P.C.E., and other physical properties.

The Fulton area was picked so that laboratory facilities will be convenient to Laclede's north and south Missouri clay deposits. Two testing kilns and other equipment will be in operation as quickly as equipment can be installed and utilities connected.

The Thiokol Chemical Corporation will market butyl rubber.

Thiokol is entering the butyl rubber field in cooperation with Petroleum Chemicals, Inc., a company jointly owned by Continental Oil Company and Cities Service Company. Petroleum Chemicals presently operates a butadiene plant at Lake Charles, La., and is a licensee under the Esso Research and Engineering Company for the manufacture of butyl rubber.

Thiokol Corporation is establishing a sales, research and development laboratory at its Trenton works to study and develop wider uses for butyl rubber. Activities will encompass selling, research and the development of new uses for butyl rubber. Thiokol also will operate a sales-service laboratory to assist purchasers in the utilization of this type of synthetic rubber.

Conoflow Corporation has appointed **Robert W. Stanton, Jr.,** as advertising manager.

Stanton, who joined Conoflow in 1954, was previously employed by Fischer & Porter Company as supervisor of direct mail advertising. Earlier, he was assistant to the advertising manager of Arthur H. Thomas Company, Philadelphia.

Stanton's duties as advertising manager include supervision and integration of the administrative and creative functions of the company's expanded advertising program.

Kaiser Steel Corporation has named **John V. Banks** as production manager of its Fabricating division, Montebello plant. Prior to joining the staff at the Montebello plant he was vice president of manufacturing for the Kaiser Motors Company. He joined the Kaiser organization in 1946 at the auto assembly plant in Long Beach. In his new position he will oversee all structural steel and special products manufactured at the Montebello plant.

Eastman Chemical Products, Inc., subsidiary of Eastman Kodak Company, has created a new chemical sales development section separate from its commercial sales department.

William M. Gearhart, formerly chief chemist in charge of the service and development laboratories of the company at Kingsport, Tenn., has been appointed manager of the new section. **R. B. Herring,** who had served as assistant to Gearhart, has been promoted to fill the position as chief chemist in charge of the laboratories, which will continue under Gearhart's supervision.

For more data on advertised products, use Readers' Service Cards, last page.

PETROLEUM REFINER Classified Ads

Petroleum Refiner New Classified Rates

RATES: Regular Classified (undisplayed) set in this size type: 12 cents per word. Minimum charge, $3. Blind box address in our care counts six words. Replies forwarded without charge. Situation wanted ads, 6 cents per word. Display ads, set in suitably larger type with ruled border, $12 per column inch; situations wanted display ads, $6 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

* * * * * * * * * * * * * * * * *

FOR SALE

■ Two—17" Lined to 16" used low pressure Clark compressor cylinders, SN 11561 and 11559, w/pistons & piston rod. For use on Clark RA-32 Gas compressors, SN 22211 & 22212. Will sell for 25% of new cost. Interested parties may contact L. T. Winter, Jr., Purchasing Agent, Texas City Refining, Inc., Box 1271, Texas City, Texas. Telephone 5-4451.

New Fractionating Tower

One (1) new fractionating tower, 5'0" I.D. x 89'6" overall height x 1⅛" plate. Thirty-four (34) bubble trays, ten (10) 18" - 300# manways. Stress relieved and built in accordance with API-ASME Code for 350 PSI working pressure. Located Wichita, Kansas.

Rock Island Oil & Refining Co., Inc.
321 West Douglas Avenue
Wichita, Kansas

WANTED TO BUY

■ Two—Used Soaking Drums, Discarded Steel Tubes, Pressure Vessels or Cracking Towers that can be machined and converted into rolls, to finish smooth O.D. 40-44 inches, one to 3" wall thickness, minimum of 34'0" long. Handholes acceptable, riveted construction can not be used. Box 238-R, PETROLEUM REFINER, Houston, Texas.

POSITIONS WANTED

■ Chemical Engineer with experience in gas plant operation, development and process engineering, employed, desires position with advancement potential in gas or petrochemical industry. Box 233-R, PETROLEUM REFINER, Houston, Texas.

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THE READER'S SERVICE CARD
For Information Concerning New Equipment and Manufacturers' Literature.

HELP WANTED

■ Chemical Engineer or Chemist for section leader in Water Corrosion Research. Fine opportunity in Philadelphia with national concern for man with 5 years corrosion experience. Supply personal and profession qualifications, a recent snapshot (not returnable) and salary desired to Box 239-R, PETROLEUM REFINER, Houston, Texas.

■ Independent refiner in Mid-Continent area has opening for Assistant Plant Superintendent. Prefer graduate engineer with minimum of 5 years experience in the operation of vacuum and atmospheric distillation equipment. Box 235-R, RETROLEUM REFINER, Houston, Texas.

■ Academic position open. Instructor or assistant professor starting September 1956 to teach Chemical Engineering and subjects related to Petroleum. Position permanent. Salary and rank depend upon qualifications. Write to Dean of Faculty, Colorado School of Mines, Golden, Colorado.

PROCESS ENGINEER

"Experienced Engineers for process design with well established manufacturer, Mid-continent area. Challenging work with excellent opportunity for advancement. All replies will be kept in strictest confidence." Box 231-R, PETROLEUM REFINER, Houston, Texas.

PROCESS ENGINEERS
Upper Midwest Refinery has openings for Chemical Engineers with up to Five years experience in process engineering, economics or operational engineering.
Please include complete resume of experience, education, salary expected and references with reply.
INTERNATIONAL REFINERIES, INC.
Personnel Department
Box No. 8, Wrenshall, Minnesota

Plant Equipment Inspectors

Graduate engineers with minimum 5 years' experience in design or inspection of petroleum processing plants and equipment. Major part of experience must have been in inspection work entailing general knowledge of all facilities. Develop inspection methods, supervise and conduct inspections and advise operations on codes and equipment limitations in a major oil installation located in Saudi Arabia.

Write giving full particulars regarding personal history and work experience. Please include your telephone number.

Recruiting Supervisor, Box 91
ARABIAN AMERICAN OIL COMPANY
505 PARK AVENUE
NEW YORK 22, NEW YORK

HELP WANTED

AREA ENGINEERS

Several graduate engineers with minimum 5 years' experience supervising maintenance engineering functions in oil refining or producing facilities, power plants, heavy industrial installations, manufacturing plants, or related operations. To establish technical supervision, procedures, maintenance operations and schedule routine and special work for major oil producing and refining operation with all supporting facilities; i.e., housing, feeding, recreation, etc.

Salary commensurate with background and experience. Write giving full particulars regarding personal history and work experience. Please include telephone number.

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NEW YORK 22, NEW YORK

Design Engineers Design Draftsmen

If you want
- HIGHEST EARNINGS
- OVERTIME WORK
- PERMANENT EMPLOYMENT
- OPPORTUNITY TO ADVANCE
- IDEAL WORKING CONDITIONS
- AIR-CONDITIONED OFFICES
- MANY OTHER BENEFITS

Please be sure to contact or see
Arthur G. McKee & Co.
with Engineering Offices in
CLEVELAND, OHIO and UNION, N. J.

McKee is a 50-year-old Engineering and Construction firm doing business on a world-wide basis.

Interesting, well-paying positions for
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The expanding McKee organization, with three engineering divisions, Refinery, Metals and Industrial, offers many interesting opportunities in these highly-paid fields.

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Combine challenging, unlimited-future job with ideal, smog-free living in San Francisco-Oakland Bay Area. Excellent salary, moving allowance, profit sharing plan and retirement, family plan hospitalization and life insurance. Must have B.S. or M.S. in chemical engineering, plus at least 10 years experience in process design with major oil company or refinery builder. Forward complete resume giving experience and salary requirement. Strictest confidence.

ALSO OPENINGS FOR REFINERY DESIGNERS AND ESTIMATORS.

KAISER ENGINEERS

Division of Henry J. Kaiser Co.
Dept. RN, 1924 Broadway
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Chemical Engineers for Process Design and Technical Service

Chemical Engineers are needed for permanent positions in the Process Design and Technical Service Departments. These groups are engaged in the design and operation of processing units in the petroleum refining industry, both domestic and foreign. Applicants with experience are desired but initiative and ability are of most importance. Some travelling required. Send details of experience, education and salary requirements. Replies will be given prompt consideration and will be held in complete confidence. Address applications to:

Engineering Division

HOUDRY

PROCESS CORPORATION

1528 Walnut Street
Philadelphia 2, Pennsylvania

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HELP WANTED

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Chemical Engineers
Mechanical Engineers
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Unlimited opportunities for advancement—applied science and engineering sales. Fast-growing service company offering chemical cleaning (boilers, lines, process equipment) to all phases of industry. Locations through most of U. S. Car furnished after training program; retirement, vacation, insurance benefits; interesting, challenging work.

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HELP WANTED

Engineer

Ch. E. and M. E.

FACILITIES SPECIALIST

Silicones are Booming!

. . . As a result, we have an immediate need for an outstanding Engineer with at least 5 years experience in process design and facilities planning. Position of Facilities Specialist will involve design and layout of the silicone plant of the future. Can be excellent opportunity for advancement to Manager or Consultant. High starting salary.

Please send resume to

BOX 236-R,

Petroleum Refiner,
Houston, Texas

PROCESS DESIGN ENGINEERS

Permanent responsible positions with opportunity for high calibre men in Engineering Department of large Gulf Coast chemical manufacturing plant. Applicants should have the following qualifications:

1. B.S. or advanced degree in chemical engineering.
2. Minimum of three years experience in process design calculations, pilot plant operations or production trouble shooting—preferably in organic plants.
3. Interest in detailed calculations and mechanical-chemical interpretation into practical designs.
4. Interest in chemical engineering as a profession.
5. Ability to work with others in a team.

Positions are in Process Design Section for work on new plants and additions to existing plants. Work includes translation of pilot plant processes into full scale plant design, design calculations on distillation, heat transfer, mass transfer, fluid flow, and associated work necessary to prepare flow sheets (no drafting). Processes are both organic and inorganic. Some field data and production equipment performance evaluation involved. Small electronic computer to be available in this work. Assignments will allow for full recognition of individual's ability, with commensurate salary.

Replies held in strictest confidence, all will be answered. Please send complete resume, including education, experience, and salary expected to Mr. D. M. Duguid, Technical Employment Manager.

Texas Division

THE DOW CHEMICAL COMPANY

Freeport, Texas

Suppliers . . .

Stauffer Chemical Company has purchased a 50 percent interest in the San Francisco Chemical Company from its parent, The Mountain Copper Co., Ltd., of London, England.

San Francisco Chemical, one of the pioneer mining concerns in the Rocky Mountain area, is a major western producer of phosphate rock. During the past several years it has been Stauffer's primary supplier of phosphate rock.

At present, San Francisco Chemical operates its own mine at Montpelier, Idaho. It also mines a Stauffer-owned claim in southwestern Wyoming and has conducted an extensive development program on Stauffer claims and leases near Hot Springs, Idaho. The Hot Springs work has already proved up large reserves of commercial grade.

Crane Company has made three new appointments to major sales posts.

Thomas D. Kelly has been appointed manager of Crane's Midwest district, and **Darrell R. Nordwall** has been named manager of the company's East Coast district. The new manager of valve and fitting sales is **Charles H. Lovelace.**

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Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.
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HELP WANTED

CHEMICAL ENGINEERS AND PROCESS SUPERINTENDENT

COMMONWEALTH OIL REFINING CO., PONCE, PUERTO RICO Require Process Engineers for technical service and process control in new completely integrated, modern refinery now expanding to 55,000 bbls. Equipment includes Catalytic Cracking, Reforming, Polymerization, Alkylation, Acid Regeneration, and SO_2 Treating.

Process Superintendent having experience to take full responsibilities of supervision of process operations.

Excellent opportunities afforded in new and growing organization. Liberal salary commensurate with qualifications.

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SUSPENDED WALLS ARCHES FOR PRESSURE VESSEL LININGS HEATERS • BOILERS

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- STACKS, BREECHINGS.
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Write for estimates on your proposed project.

GEO. P. REINTJES CO.
REFRACTORY WORK SINCE 1920
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WAX PRESS FILTER BLANKETS

- Made only of first grade hydraulic press 12/0 duck
- Fabricated to your specifications
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Write today for the Schotco story

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WEST SALEM, OHIO

TO REPAIR PIPE LEAKS – QUICKLY, PERMANENTLY
ANY PRESSURE — ANY TEMPERATURE

SKINNER-SEAL EMERGENCY PIPE CLAMP for pinhole or corrosion leaks.

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In stock — all supply stores

M. B. SKINNER COMPANY
SOUTH BEND 21, INDIANA, U. S. A.

ERNST
HIGH PRESSURE GLASSES and GASKETS

All sizes to fit your gages and valves

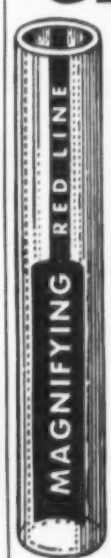

FIG. 22 SERIES 750

FIG. 21 LIP-MOLD

STATE YOUR REQUIREMENTS

All shipments from stock.
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ERNST WATER COLUMN & GAGE CO.
Livingston 6-1400 LIVINGSTON, N. J.

For more data on advertised products, use Readers' Service Cards, last page.

What's New in Equipment . . .

. . . and Manufacturers Literature

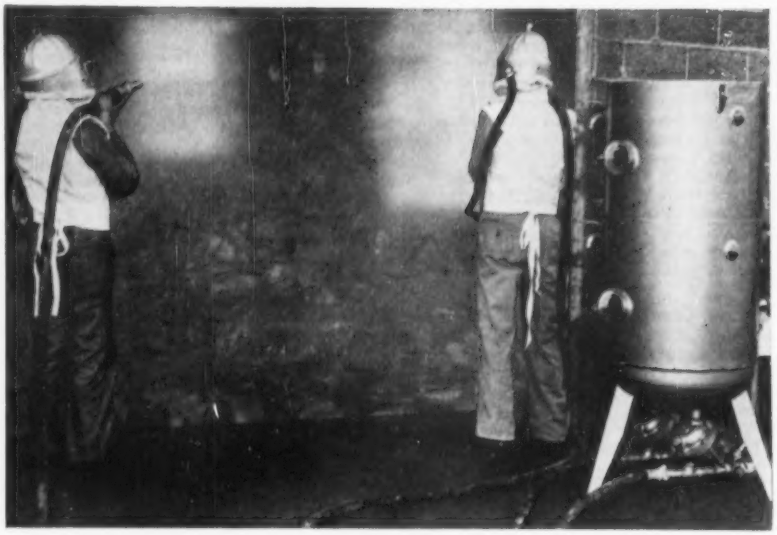
Steam-Jet Refrigeration—This 24-page bulletin, Form 9143-B, describes the operation and advantages of steam-jet coolers for supplying commercial quantities of chilled water. Water as low as 35 F for chemical plants, synthetic rubber plants, air conditioning, SO_2 recovery and many other uses can be supplied wherever a supply of steam is available. Since cooling is obtained simply by the movement of vapors and liquids, there are no moving parts within the machine. This means that installation and operating costs, and maintenance and cleaning costs are substantially reduced. Units are available for any rating between 30 and 1200 tons of refrigeration. Ingersoll-Rand.
Circle E1 on the Card.

Demineralization—All phases of demineralizing plus advantages and disadvantages of this process are discussed in a new 24-page, fully illustrated article—Technical Reprint T-140.

The paper considers some of the developments, trends and applications of both multi-bed and mixed-bed ion exchange and uses several case histories as examples. A complete comparison of the two types of demineralizing systems is presented as well as some of the important factors that go into the chemical and mechanical design and operation of these units.

The bibliography alone makes this paper a valuable addition to your library—119 separate items are included. In addition, several valuable tables, flow sheets, performance curves, and cutaway views are shown. Graver Water Conditioning Company. **Circle E2 on the Card.**

Muffler Removal—A new muffler remover tool that can cut installation time in half is now available to dealers. The handy tool, which allows the operator to easily slash through old pipe and muffler nipples, eliminates the use of solvents or unwieldy wrenches. The AP Parts Corporation. **Circle E33 on the Card.**



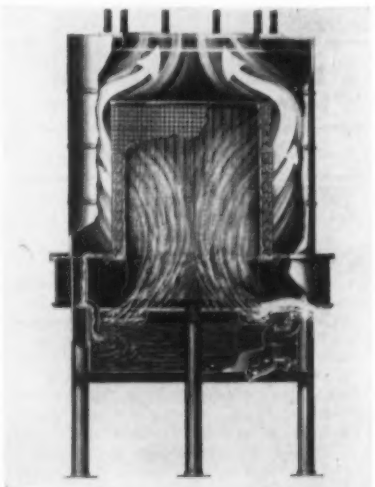
Dual Operator Sandblast Machine
Two sandblasters may now blast from one pot. Equipped with two blast hoses working off two sand control valves, these machines are double chamber types holding 1000 pounds of sand with automatic pop-up filling valves and 1¼ inch piping. All blasting is done from the bottom chamber which permits refilling of the upper chamber without interrupting the sandblasting. The abrasive in the upper chamber automatically transfers to the lower chamber. Mounted on three legs and equipped with lifting ears these units are designed for the large scale users. If desired only one hose can be operated. Clementina, Ltd. **Circle E3 on the Card.**

Very High Temperature Castable
A new high strength tabular alumina castable for refinery applications up to 3400 degrees has been developed. Puro-TAB is a high-purity, low-iron super alumina castable. It has as its base a tabular alumina aggregate bonded with a high-purity calcium-aluminate binder (no acid).

Shipped in 100-pound moisture-proof bags, the new castable can be placed by pouring or extruding. Reducing atmospheres or carbon deposition are said to have no effect and high resistance to abrasion is claimed. It is adapted especially to atmospheres of high sulfur fuels and charge stocks. Mexico Refractories Company. **Circle E4 on the Card.**

High Speed Mechanical Drive Turbines—A new publication designated GEA-6232 describes high speed mechanical drive turbines operating at speeds ranging up to 10,000 rpm and above. Construction and design features of turbine drive for centrifugal compressors and blowers are covered in detail in the new bulletin.

Cross sections, schematic drawings, cutaways, and typical installation photos point out design features and applications for single-valve, single and multi-stage turbines, as well as multi-valve multi-stage and multi-valve single-stage units for high back pressure applications. General Electric Company. **Circle E5 on the Card.**



Compressor Air Filter—A new oil bath air filter which combines high efficiency with extremely low pressure loss has been developed. The new filter achieves low-pressure-drop operation without any moving parts or any outside energy supply. The result will be to make economical oil bath filtration available for use with a

IN-PLACE CHEMICAL CLEANING

now your quickest way to declog dirty heat exchangers like this

With Oakite chemical circulation method you can now clean heat exchangers in place. And here are a few of the many advantages awaiting you:

- **fast, thorough soil removal**
- **greatly reduced off-stream time**
- **elimination of costly manual methods**
- **greater safety and longer life for tube bundles**
- **plus the supervisory services of an experienced Oakite technician**
- **free drawings and control equipment**

For the complete story on heat exchanger cleaning by Oakite send for new 48-page Booklet "What Petroleum Men Should Know to Simplify Cleaning". Or write for the name of your local Oakite Technical Service Representative. No obligation. Oakite Products, Inc., 44C Rector Street, New York 6, N. Y.

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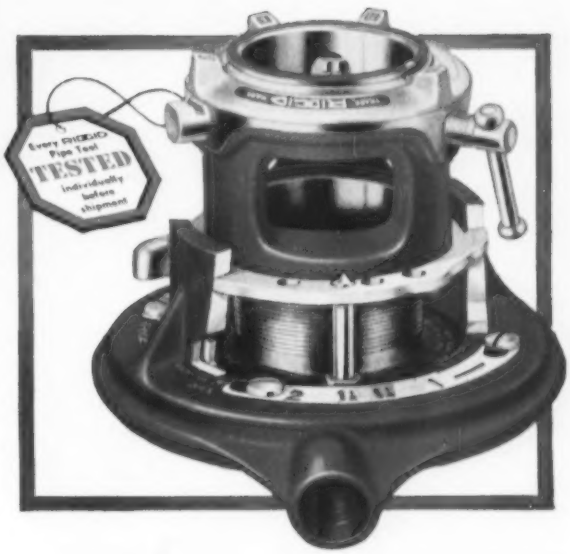
Nearest Thing

to Machine Pipe Threading



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Jam-Proof 65R

saves you time, work and mistakes

Ready for work fast—you set 65R to pipe or conduit size in 10 seconds . . . self-contained 1″, 1¼″, 1½″, 2″ high-speed steel dies. Self-centering workholder sets to size instantly.

No mistakes—automatic kick-out prevents jamming when standard thread is cut. Workholder setting is mistake-proof.

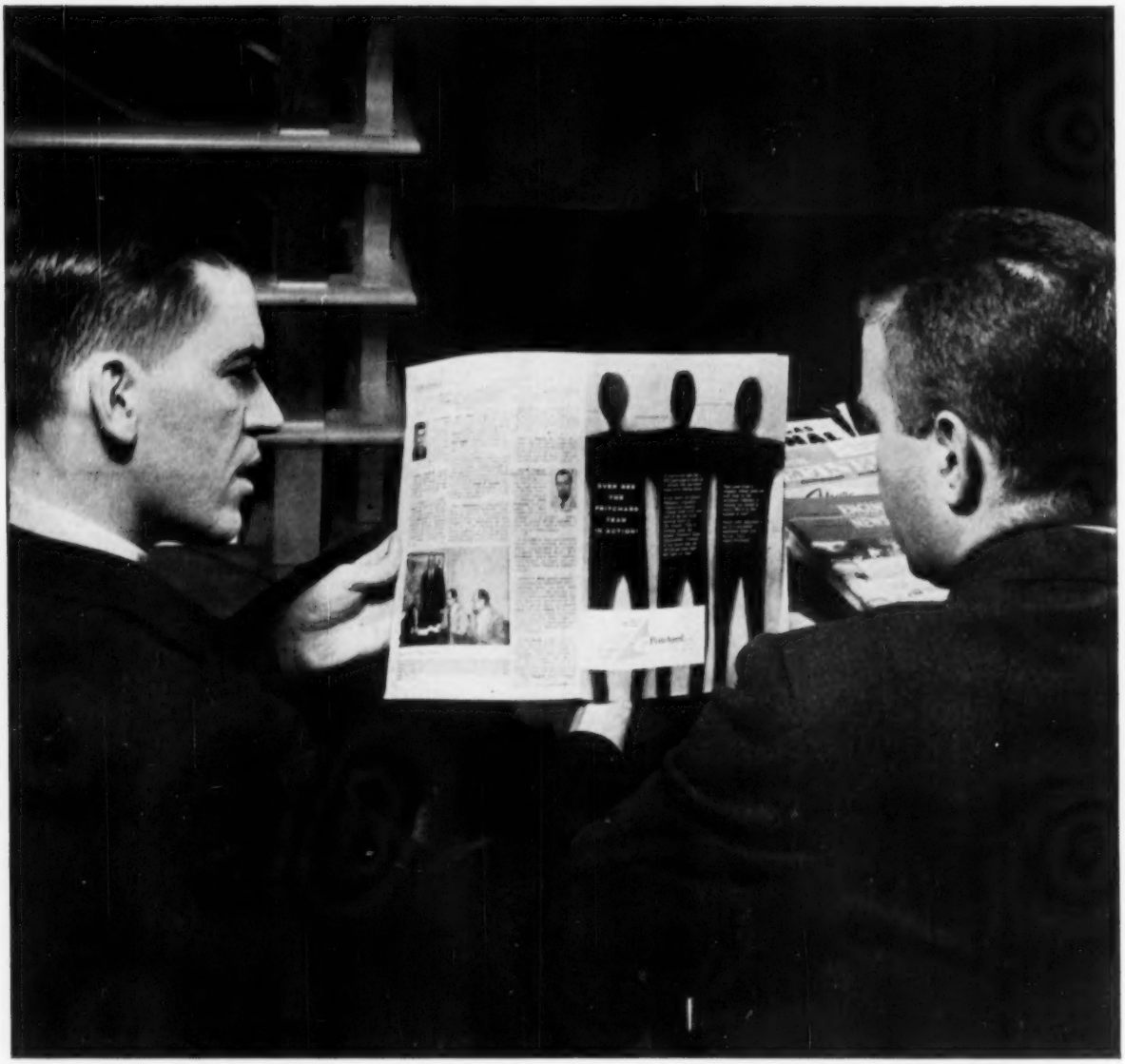
Beautiful threads—perfectly threaded factory test sample in your new 65R proves it!

You can't beat RIDGID 65R for speed, easy work and long service. *Buy it at your Supply House!*

RIDGID
Work-Saver Pipe Tools

The Ridge Tool Company, Elyria, Ohio, U. S. A.

For more data on advertised products, use Readers' Service Cards, last page.



"What do they mean by the 'Pritchard Team', Scotty?"

"What makes you ask?"

"I was just looking at this Pritchard ad, and it says, 'Ever See the Pritchard Team in Action?' and then it goes on to say, 'designers, engineers, construction superintendents work *with* your staff all the way from drawing board to on stream.'

"I keep forgetting that you've never seen Pritchard at work on a job. What they mean is that the Pritchard people work as a unit. And they work very closely with their clients' personnel, from the planning stage right down to the finished job. I've worked with them before, and I know why they call it a 'team'."

"I can see that you're sold on Pritchard, aren't you, Scotty?"

"You bet I am, and you will be too, when you see the Pritchard team in action."

"That'll be soon, too! They're working with us on our new plant."

J. F. PRITCHARD & CO.
4625 Roanoke Parkway, Kansas City 12, Mo.

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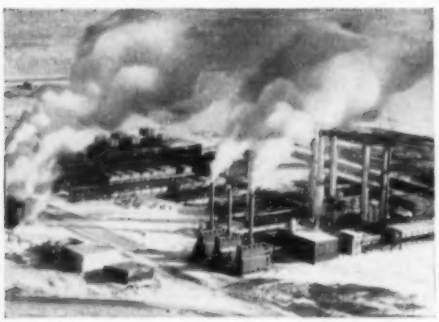
"What do they mean by the 'Pritchard Team', Scotty?"

Pritchard is ready to serve you now in the following Petroleum Processes!



OIL FIELD PROCESSING

- Pressure Maintenance
- High and Low Pressure Recovery Systems
- Crude Stabilization
- Natural Gas Dehydration
- Sulphur Removal
- Light Hydrocarbon Recovery
- Elemental Sulphur Recovery
- Hydrocarbon Dew Point Control

REFINERY PROCESSING

- Distillation and Recovery Systems
- Thermal Reforming
- Cracking and Viscosity Breaking
- Catalytic Reforming
- Alkylation
- Polymerization
- Isomerization
- Crude Desalting
- Catalytic Desulphurization
- Lube Oil Desulphurization Handling and Packaging

PLUS . . . many types and facets of refinery offsite facilities construction.

Write for TIOGA Brochure

TIOGA

This interesting booklet describes and illustrates the Signal Oil & Gas Company's natural gasoline, H_2S removal and sulphur recovery plant at Tioga, N. D. Write for your complimentary copy on your company letterhead.

INDUSTRY'S PARTNER FOR PROGRESS

J.F. Pritchard & Co.
ENGINEERS • CONSTRUCTORS
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Kansas City 12, Mo.

SERVING THE GAS, POWER, PETROLEUM AND CHEMICAL INDUSTRIES
BOSTON, CHICAGO, BUFFALO, HOUSTON, NEW YORK, PITTSBURGH

New Equipment . . .

much broader range of compressors, blowers and engines.

Oil scrubbing has long been an accepted method of cleaning intake air, but in the case of some equipment (such as turbocharged stationary engines) the energy required for oil-bath filtration—in the form of static pressure loss—has been too great to tolerate. Until introduction of the LPD filter, the only solution was to supply the required energy from an outside source in the form of a moving curtain or motor-driven oil pumps.

In this filter, air is drawn in under a weather hood set low on the unit and is directed through an air-flow regulator tube to an oil control pan. Here the air picks up droplets of oil which are carried up through a diffuser cone where air and oil are thoroughly mixed and the air is scrubbed. The air then passes through the cylindrical filtration element where dirt particles and oil droplets are removed, permitting only clean, oil-free air to flow to the engine, blower or compressor. Oil and the dirt it has collected flow down inside the filtration element and through oil-return pipes to the sump where dirt settles out. Clean oil is metered from the top of the reservoir into the oil control pan through calibrated holes in the sides of the pan. Air Maze Corporation.

Circle E6 on the Card.

Waterproofing—An improved waterproofing material called Meco Sealtite sets in five minutes or less and bonds perfectly to concrete or other masonry walls or floors to eliminate dampness or active water leakage.

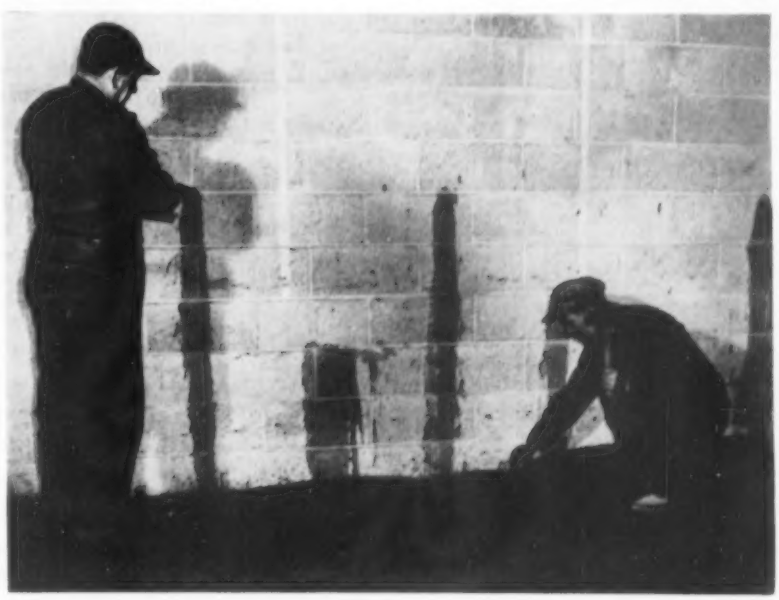
This material makes waterproofing inexpensive, can be applied quickly and easily, and will permanently seal masonry walls against hydrostatic pressure. Because of its excellent bonding qualities and quick-setting ability, the use of forms and other braces can almost always be eliminated.

Generally the application below grade is by sealing the cracks with the quick-setting mortar produced, or by plaster-coating walls that are or can be made free of hydrostatic pressure at the time of application. To waterproof blocks above grade, application is generally made by brush except in cases where holes or mortar joints need filling. Sealtite is used to stop or prevent leaks in dams, basements, elevator pits, tunnels and mine shafts, and is used to waterproof reservoirs, wells, tanks, aqueducts and other similar types of structure. It is supplied in liquid form and mixed with Portland cement for severe conditions, or with Portland cement and sand for ordinary conditions. Maintenance Engineering Co.

Circle E7 on the Card.

Above Ground Manhole Condulets—Designed to replace conventional below-ground manholes, this type GUB above-ground manhole condulet provides a simple, inexpensive means for splicing main electrical feeder cables and making branch taps.

Besides avoiding the difficulties of dealing with gas contamination or the ac-



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DO IT YOURSELF!!

MAKE YOUR OWN PUMP SEAL SELECTIONS!!

The new Sealol Flexibox Sealector enables you to decide on seal type, size, and materials for your specific requirements. The Sealector covers 48 typical products being handled in the process industries.

HERE'S HOW IT WORKS—

Typical Example . . . Butane 250 PSIG @ 160°F Shaft Size 1⅝"

1. FRONT

STEP I — Automatic selection of seal type and material — set pointer on product:

TYPE

RRCB FLEXIBOX
RR = BALANCED DESIGN
C = CIRCULATED PRODUCT
B = THROTTLE BUSHING

MATERIAL

STATIONARY SEAL RING	CARBON
ROTARY SEAL RING	TYPE 347 STAINLESS STEEL
ROTARY SEAL RING FACE	STELLITE
SPRING	TYPE 18-8 STAINLESS STEEL
GLAND PLATE	STEEL, PLATED
O RINGS	BUNA BASE RUBBER

2. BACK

STEP II — Determine seal size from shaft dimension:

TYPE = RRCB
SHAFT = 1.625"
MIN. STUFFING BOX BORE = 2.625"
MIN. BOX DEPTH = 2.625"
SEAL SIZE = 40

Send for your Sealol Flexibox Sealector on your letterhead today — at no charge.

SEALOL CORPORATION,
185 POST ROAD, PROVIDENCE 5, R. I.

New York • Philadelphia • Cleveland • Chicago • Norfolk
Charleston (W. Va.) • St. Louis • Kansas City • New Orleans • Dallas
Houston • Tulsa • Los Angeles • San Francisco • Seattle • Edmonton
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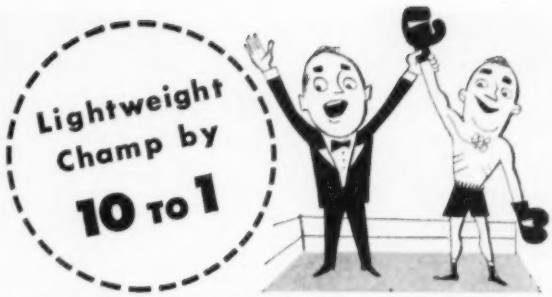
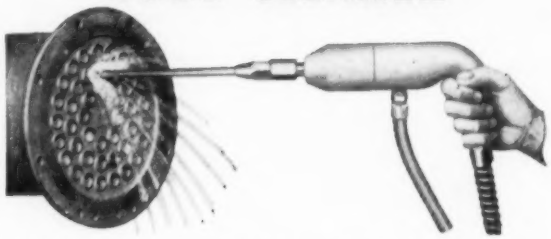
SEALOL

THE BALANCED PRESSURE SEAL



WILSON PGX

TUBE CLEANER



The Wilson PGX Tube Cleaner weighs only 6½ pounds, but it knocks out scale ten times faster than ordinary mechanical cleaners. It cleans at rates as high as ten feet per minute—removes deposits from flinty hardness to soft gum as well as chemical compounds such as carbonates, sulphates, sulphites, silicates, chlorides, coke, marine growths and iron oxides.

In the range between ½" and 1½", few jobs are too tough for the versatile and rugged PGX cleaner. The work is done by a long-wearing carbide cutter bit and a stream of air or water forced under high pressure through a hollow shaft and beyond the cutter tip. It flushes as it cuts—no need to worry about jammed, burned-out bits—no need for lengthy, expensive preliminary work to prepare the tube for cleaning.

Don't let valuable equipment stand idle for days while you struggle with inadequate cleaning tools. Put the pressure on with PGX.

Also ask about two teammates of the PGX—the PG for ½" to 1" ID and the TP 301 for ⅜" to 2" ID. All three models can be fitted with accessory expanding brushes and expanding scrapers. These and scores of other tube maintenance tools are described in the new, free Wilson Catalog 77. Write for it today.

Representatives in principal cities

THOMAS C. WILSON, INC. • 21-11 44th Ave., Long Island City 1, N.Y.
Cable address: "Tubeclean", New York

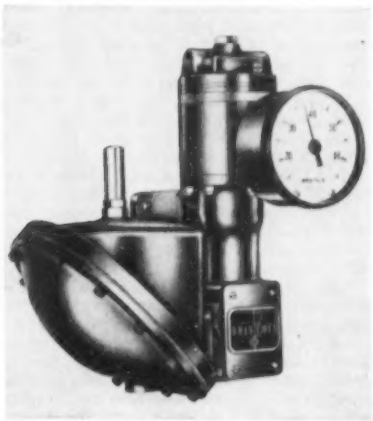
WILSON TW-852

TUBE CLEANERS • TUBE EXPANDERS

New Equipment . . .

cumulation of water which so often are present in underground manholes, the above-ground feature of the new manhole cover allows maintenance personnel to easily inspect connections at any time.

The interior of the above-ground manhole does not require filling with hot insulating or waterproofing compounds. Moreover, the new above-ground condulets can be installed singly or in groups to accommodate the same number of feeders and branches for about one-fourth the cost of below-ground manholes. Crouse-Hinds Company. **Circle E8 on the Card.**



Absolute Pressure Transmitter—A new absolute pressure transmitter, which will measure pressures in ranges as low as 0 to 5 mm Mercury Absolute, and transmit the measurement as a 3-15 psi pneumatic signal to an automatic controller or receiver, has just been announced.

The Metagraphic Absolute Pressure Transmitter is offered to handle pressure ranges from 0-5 mm Hg to 0.760 mm Hg. It transmits a universal 3-15 psi pneumatic signal, and can be used with any standard pneumatic receiver or automatic controller.

A full line of such indicating and recording receivers and automatic controllers are also offered in the Metagraphic line. The Bristol Company.

Circle E9 on the Card.

Standard Heat Exchangers—A new 18-page brochure, Bulletin M-306, on "Lummus Standard Heat Exchangers for Process Industries" has just been issued.

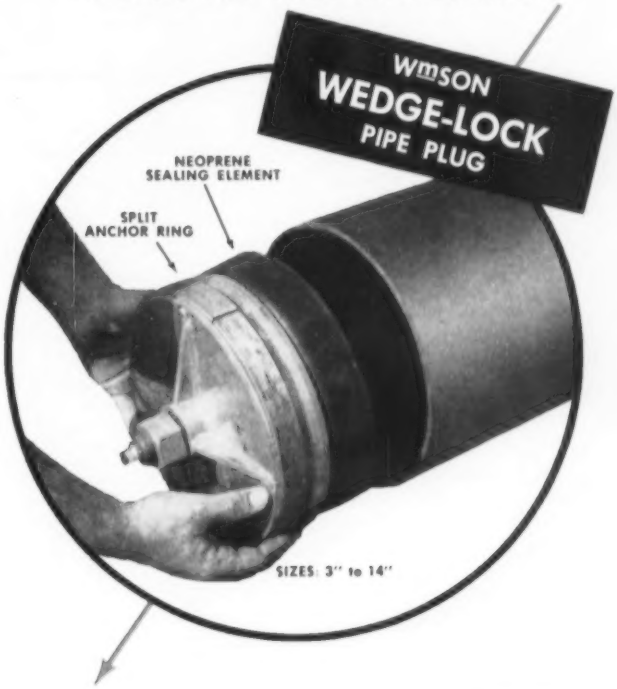
It includes: A description of the design specifications and construction details of these standard units; tables of effective surface area available in the various units; tables of overall dimensions for these exchangers; and thermal design data, with tables of film co-efficients, pressure drops, fouling factors, and tube characteristics necessary to solve the basic heat transfer equations. The Lummus Company.

Circle E10 on the Card.

Stainless Steel Pipe—Engineers and others associated with the design or maintenance of processing equipment and piping will be interested in this eight-page technical folder just issued. The bulletin, known as TB-410, deals with the use of seamless and welded stainless steel pipe

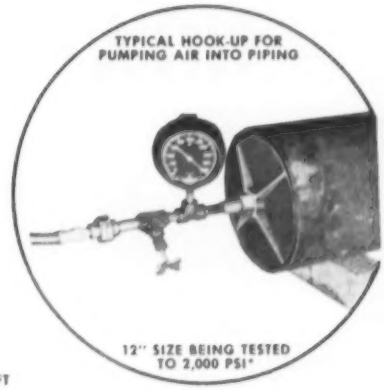
Here's a better way...

TO PLUG PIPE ENDS TEMPORARILY

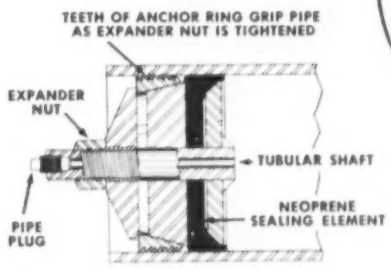


In Order To:

- REPAIR PIPING
- ADD FITTINGS
- TEST PIPING & VESSELS
- PROPEL PIGS BY COMPRESSED AIR



*COLD WATER, NON SHOCK TEST MADE IN 12¾" O.D. STANDARD WEIGHT LINE PIPE.


TEETH OF ANCHOR RING GRIP PIPE AS EXPANDER NUT IS TIGHTENED
EXPANDER NUT
TUBULAR SHAFT
NEOPRENE SEALING ELEMENT
PIPE PLUG

WRITE FOR BULLETIN AND PRESSURE RATINGS OF ALL SIZES

T.D. Williamson, Inc.

P. O. BOX 4038 — TULSA 9, OKLAHOMA

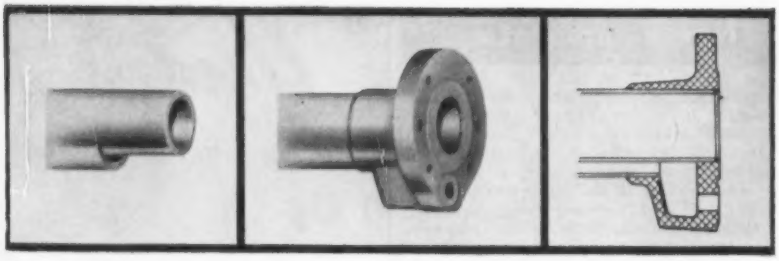
REPRESENTATIVES: Houston • Pittsburgh • Plainfield, N. J. • Amarillo • Casper • Provo, Utah • Joliet, Illinois • Los Angeles • San Francisco • Bartlesville, Okla. • Edmonton • Toronto Calgary • Buenos Aires • Durban, Natal, South Africa

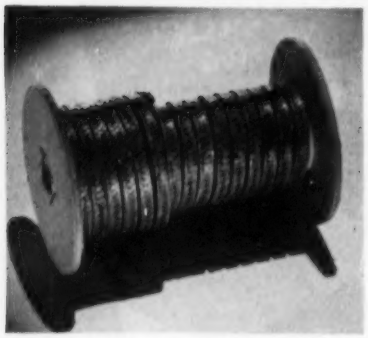
For more data on advertised products, use Readers' Service Cards, last page.

New Equipment . . .

and stainless steel welding fittings in the process industry where corrosion and/or elevated temperatures are determining factors. The folder contains application data on the most widely used stainless steels and furnishes helpful hints on the bending, joining and welding of these products. Babcock & Wilcox Company.

Circle E11 on the Card.





New Chemical Packing—A newly-developed fiber used in this mechanical packing offers greater corrosive resistance and service life. The packing is a braid over braid of glass and Teflon—two of the most inert fibers.

The fine pure Teflon fibers braided over a core of glass fibers and impregnated with Teflon presents a soft pliable low friction packing that is excellent for use on centrifugal as well as reciprocating and static applications.

This new packing gives excellent performance under wide environmental conditions of temperature and chemical exposure. Concentrated acids such as sulphuric, nitric, sodium hydroxide, aqua regia; alkalies, and practically all solvents simple or complex are easily handled. Abbott & Biddle.

Circle E12 on the Card.

Electronic Temperature Controller—Specification Sheet S1010-1 describes the Model 077 electronic temperature controller. This is a non-indicating device, which operates on the balanced bridge principle. It can be supplied as a single point controller, using a single bulb, as a differential controller, for control on the temperature difference between two bulbs, or for cascade control, using two bulbs. Minneapolis-Honeywell Regulator Company.

Circle E13 on the Card.

Integral Traced Aluminum Pipe Flanges—A new method for simple and efficient joining of Unitrace sections has been introduced. Unitrace, introduced two years ago by Aluminum Company of America, is an integrally extruded steam traced aluminum pipe, which permits easy application of heat to product piping.

The new joining system involves a special cast flange manufactured in alloy A356-T6. The flange features a built-in product and steam tracing line.

To join two sections of pipe, the trace lines are cut back approximately 2½ inches from the ends of the sections to be joined. The flanges are then slipped onto each section end. The pipe sections and the flanges are joined by welding at the front faces and necks of the flanges using 4043 weld wire.

Two separate gaskets are used to seal the product and steam passages between the mating flanges. Bolt holes on these flanges will mate with standard 150 pound 2-inch ASA pipe flanges and fittings to permit easy joining to other piping and equipment. Condensate drains can readily be installed by drilling into the steam cavity of the flanges.

Main advantage to the new system is that it prevents "freezing" of the product in the space between pipe sections, since the new flange carries its own steam trace line.

A stainless steel impingement plate is incorporated in the steam cavity of the flange to eliminate erosion by steam condensate. Aluminum Company of America.

Circle E14 on the Card.

Determination of CO_2—Technical Paper 133 entitled "Determination of Carbon Dioxide in Water by Conductivity Measurements" describes a new method developed for the determination of carbon dioxide which is applicable to analysis of waterside deposits, treatment chemicals and organic carbon in water. The principle of differential conductivity permits rapid, accurate analyses. W. H. & L. D. Betz.

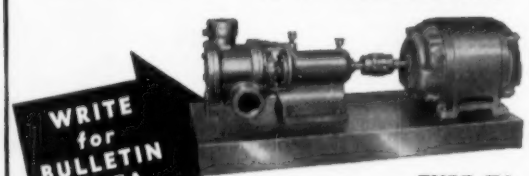
Circle E15 on the Card.

PVC Pipe and Fittings—Two types of unplasticized polyvinyl chloride pipe and fittings are described in this new product bulletin. One type is a normal impact grade, and the other a high impact grade. The bulletin gives general descriptions, advantages and applications. Tables give such technical data as physical properties, dimensions and weight, and working pressures. The Carpenter Steel Company.

Circle E-16 on the Card.

Vinyl Electric Tape—A complete line of vinyl electric tape is available in both 8 and 10 mil thicknesses and in all popular sizes. It can be purchased in individual packages—one 66-foot roll per can—or in a convenient five 30-foot rolls

NOW! *The handling of liquefied petroleum gases, refrigerants and other light non-viscous liquids* **is a CINCH!**



TYPE Z4

APCO *Process* PUMPS

•

SPECIAL METALS

APCO'S are obtainable in any machineable alloy. Small amounts required. Result: ECONOMY.

New and difficult applications in modern industry pose a challenge to pump designers. Aurora engineers have met this challenge completely with the APCO TYPE Z4 Process Pumps — which combine the ideal turbine-type features, special metals where required, single mechanical seal and other latest design features for SURE RESULTS. We invite your inquiry.

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AURORA PUMP DIVISION
THE NEW YORK AIR BRAKE COMPANY

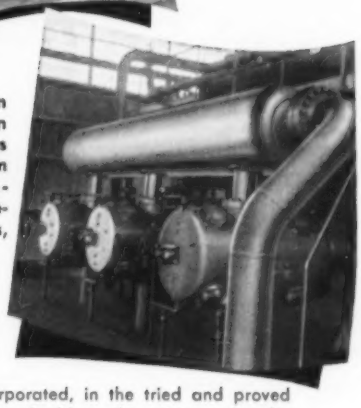
84 LOUCKS STREET • AURORA • ILLINOIS

INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

NOISE and PULSATION engineered right out of existence!

Our specialty is analyzing and correcting problems of:

(1) Intake and exhaust noises of air, steam and gases from compressors, blowers, jets, turbines, engines, etc.



(2) Piping pulsation and vibration caused by surges emanating from pumping equipment, pressure reduction operations, etc.

We have incorporated, in the tried and proved Burgess-Manning Snubber, the science of pulse and slug arresting that has saved industry many dollars in increased production, decreased maintenance, elimination of compensation claims and improved public and employee relations.

Burgess-Manning Snubbers are specially engineered to your problems and may be had to integrally include many plus features such as: air cleaning, or spark arresting, or water separating, or heat recovery.

Let us tell you how Burgess-Manning Snubbers will solve your problems of Noise and Pulsation.

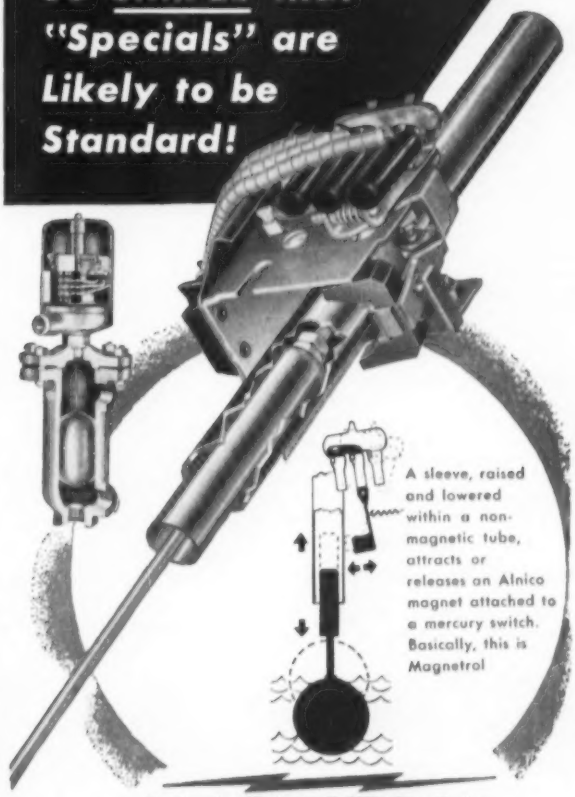
Write for literature and free case history material

BURGESS-MANNING COMPANY

Sound Engineering

711 East Park Avenue, Libertyville, Illinois
Dallas, Texas

So SIMPLE that "Specials" are Likely to be Standard!


A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol

MAGNETROL

The World's Most Dependable

LIQUID LEVEL CONTROL

Because of the utter simplicity of Magnetrol's magnetic operating principle, standard models can be easily adapted to meet any special requirements for pressure, temperature or corrosive liquids . . . and usually at little extra cost. This Magnetrol versatility has solved all kinds of tough level control problems . . . and given our engineers wide application experience that can be invaluable to you.

Magnetrol is so simple that failure is all but impossible! Using only permanent, unfailing magnetic force for its operation, there's nothing to wear out . . . no diaphragms or bellows to stiffen and rupture . . . no electrodes to short or corrode . . . no packing to bind or leak. Magnetrol is practically maintenance-free! Magnetrol units are available for controlling level changes from .0025-in. to 150-ft. . . . with multi-stage switching when desired. Send coupon for full details.

MAGNETROL, Inc.

Send Coupon For Full Details

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There is a wide usage for this new tape. It is recommended in place of friction and rubber tape where abrasion exists or where tape is subjected to water, acids, alkalis, or corrosion. It is especially recommended in all cases as a neater, more efficient installation. Vinyl tape is tested to 10,000 dielectric volts and, therefore, requires much less wrapping than friction and rubber. Vinyl tape's longer lasting qualities, both in use and in the amount needed to complete a splice, make it more economical than friction and rubber. Quaker Rubber Division, H. K. Porter Company, Inc.

Circle E17 on the Card.

Prestressed Concrete Tanks—New four-page technical bulletin T-12 describes current trends in the design and construction of prestressed concrete tanks including illustrations of typical tanks and standpipes. Information on estimating and economics is also included. The Preload Company, Inc. **Circle E18 on the Card.**

Microballoons—Crude oil saved in less than two years can recover the cost of installing microscopic plastic spheres in a storage tank, according to a new booklet entitled "The Microballoon Layer Reduces Evaporation Losses."

The tiny spheres are made of Bakelite phenolic resin and filled with sealed-in gas. Pumped or dumped into the tank, millions of the spheres form a surface blanket which field installations show can cut crude oil losses as much as 80 to 90 per cent.

The 12-page booklet employs graphs, tables and photographic illustrations to describe the spheres themselves; how they are packaged, shipped, stored, installed, and maintained in crude oil tanks, and even how a specially designed portable gauge well measures the oil in a tank covered with Microballoon spheres. Bakelite Company, Division of Union Carbide and Carbon Corporation.

Circle E19 on the Card.

Magnetic and Motorized Valves—This new 20-page Catalog No. V-55 illustrates and lists specifications of magnetic and motorized valves for use with air, water, gas, steam, oil and refrigerants. The Mercoid Corporation.

Circle E20 on the Card.

Diesel-Engine Spectrograph—A new, automatic instrument which many believe will revolutionize diesel engine maintenance procedures is now being manufactured. The instrument, called the "Quantometer," is being used to check condition of diesel engines by thorough analysis of crankcase oil.

The Quantometer, using only a half teaspoon of sample oil, provides a complete quantitative analysis in two minutes, recorded on a direct reading chart. Correlation of the analysis with known engine data then enables engineers to detect wear and other factors before there is a chance of engine damage. The instrument permits great savings in time over usual procedures and, since it detects elements to the millionth part, it provides immediate data not readily obtained by other methods. A reading which deviates from a known standard is thus the earliest indication of incipient trouble.

The instrument is set to obtain quantitative readings on 16 elements, and elimi-

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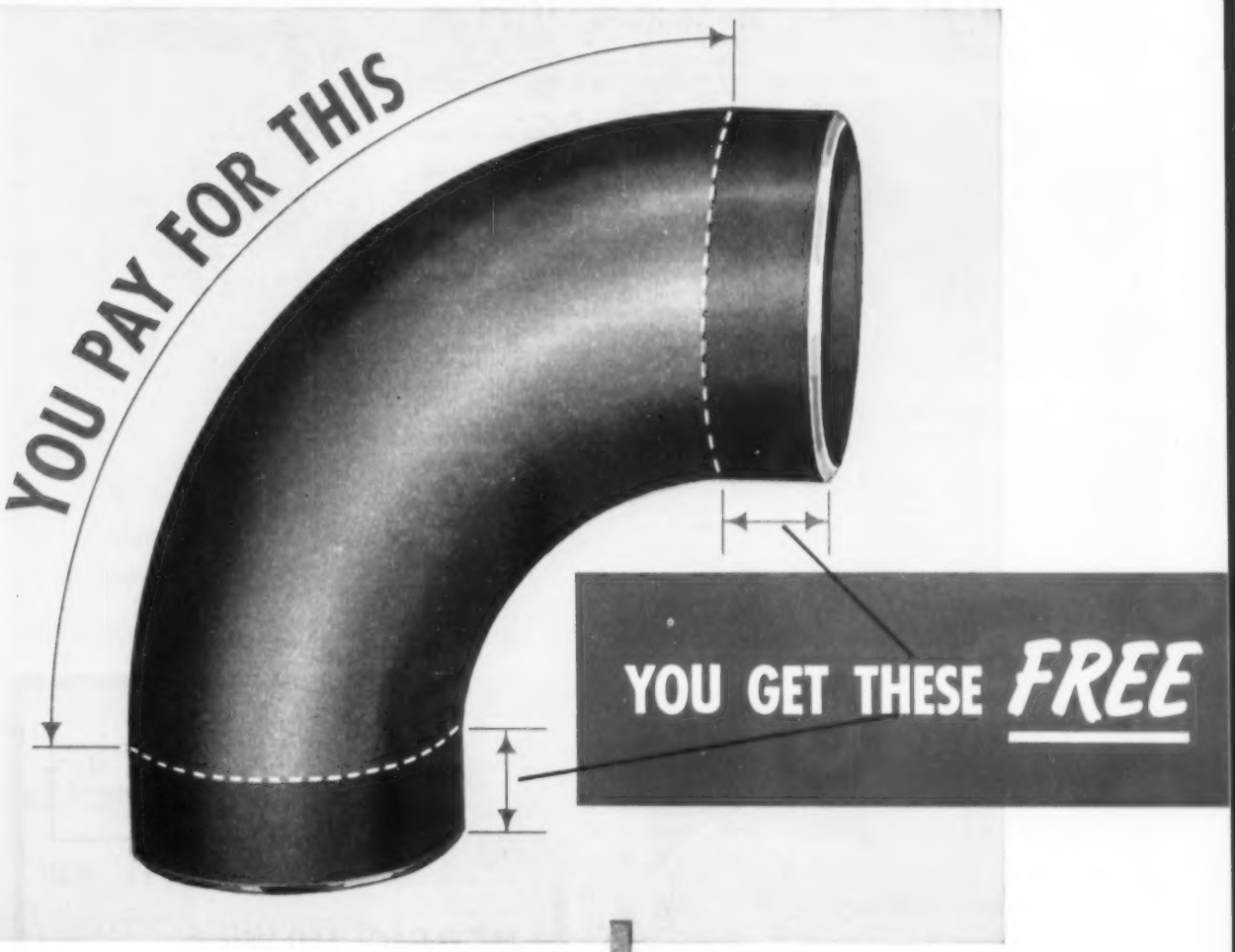

In no other welding elbow do you get this "bonus" of long tangents. The dotted lines show where standard elbows end. Each shaded straight end equals ¼ of the nominal fitting diameter . . . a 12″ Midwest "Long Tangent" Elbow has tangents 3″ long. As a result of the advantages listed at the right, substantial savings are made on many piping systems by using Midwest "Long Tangent" Elbows . . . which cost no more than other elbows. For further information, write for Catalog 54.

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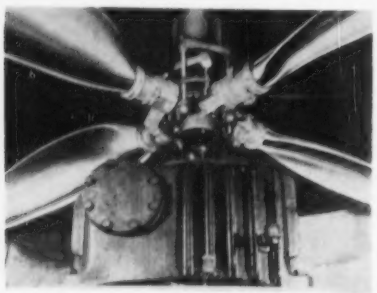
nates need for photographic procedures and densitometer measurements. Operating on the optical emission principle, the unit consists of three sections: Multisource unit, spectrometer and recording console. Applied Research Laboratories.

Circle E21 on the Card.



Controllable Pitch Fan—Bulletin A-113 describing a new controllable-pitch, air-cooled, heat-exchanger fan is now available. This fan was introduced in response to a long standing need in the process industries for a precise method of maintaining fluid outlet temperatures.

Variable air delivery is accomplished by the variation in blade pitch setting. The fan assembly responds instantly and automatically to conventional control equipment, increasing blade pitch to deliver more air when the outlet temperature rises, decreasing blade pitch and delivering less air when the outlet temperature falls.

This pitch-change technique, and the pitch change mechanism, are highly adaptable to precision control. On test installations these controllable pitch-fans have proved their ability to hold outlet temperature fluxuation to a plus or minus 1½ F when used with adequate temperature sensitive controls.

Under many operation conditions, these fans consume up to 50 percent less power than that required by conventional fixed-pitch fans. Hartzell Propeller Fan Co.

Circle E22 on the Card.

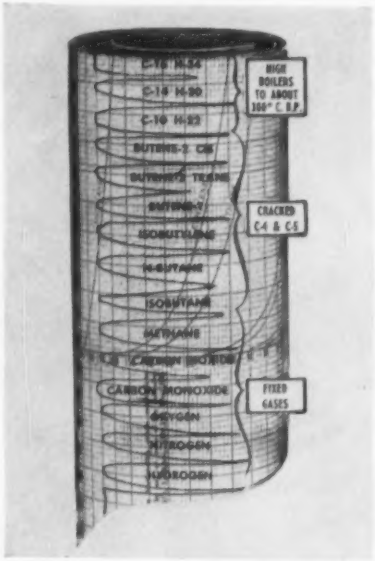
1956 Chemical Catalog—Over 7300 chemicals—everything from "workhorse" technical grades to radioactive reagents and unique spectroscopically-pure solvents—are listed in this new 370-page book. Almost every chemical that is commercially available and of use to science, from Acenaphthene to Zirconyl Nitrate—plus bacteriological culture media, fluid extracts, spirits and tinctures are covered.

A handy reference book, Catalog 120-C gives structural formulas, formula weights, melting and boiling points, and color-index numbers. Fisher Scientific Company.

Circle E23 on the Card.

Hydromatic Valve—A new publication describes Hydromatic valve used in the control of demineralizers, zeolite softeners, dealkalizers and pressure filters. The valve has been developed to eliminate the complicated nest of individual valves required for the control of the various stages of service, backwash, regeneration, rinse and return to service. The new valve can be operated either automatically or manually. The publication describes the design features, operation and advantages this valve offers operators of ion exchange equipment. Cockrane Corporation.

Circle E24 on the Card.



Vapor-Phase Chromatography—Three new apparatus for analysis by vapor-phase chromatography have been developed. The Series 9400 Chromacon has a

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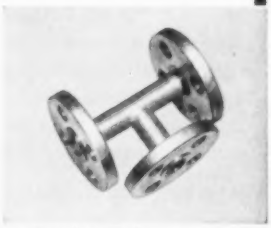

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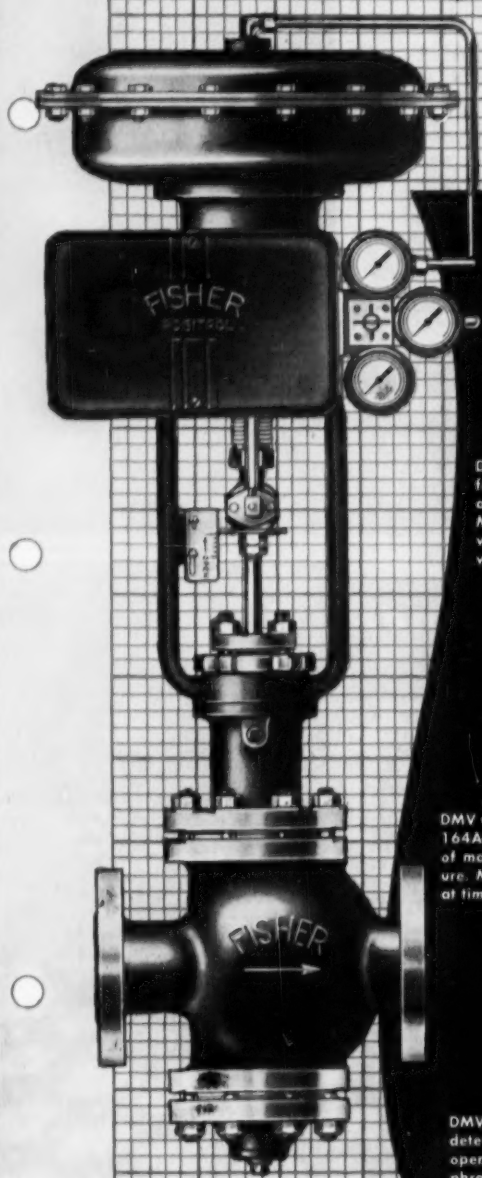

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DMV with Hand Jack Operator. Allows for manual operation against spring action. Limits travel of valve. Example—Maximum opening in spring opened valve. Minimum closing in spring closed valve.

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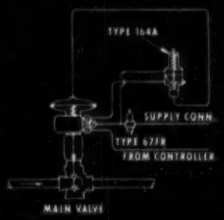
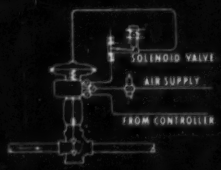
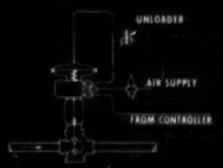


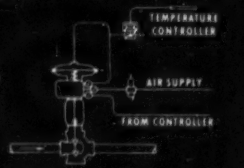
DMV with Air Lock-up system using Type 164A to close air circuit to diaphragm of main valve in case of plant air failure. Main valve will be held in position at time of supply pressure failure.



DMV with Remotely Actuated Electric Solenoid Trip Out. Valve may be fully opened or closed by unloading operating pressure from diaphragm by solenoid operation. Solenoid is actuated from manual switch or an electric tie-in circuit.



DMV with Air Cut-out Feature. At predetermined pressure setting, unloader opens and bleeds pressure off diaphragm to keep main valve open. Unloader orifice is larger than controller orifice so main valve remains open. Operation restored by putting thumb over open end of unloader.



DMV with Auxiliary Controller Override. An auxiliary controller, such as temperature, placed in operating air line to diaphragm—can over-ride action of main control function by unloading diaphragm and taking over functional operation of DMV.

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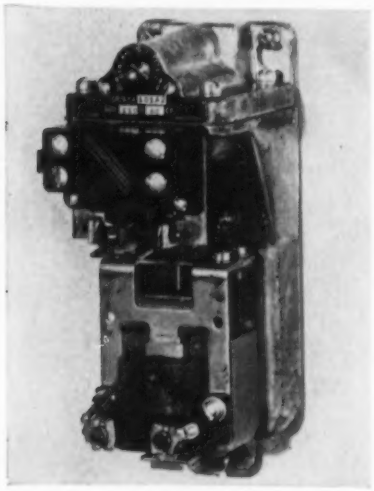
column and detector cell contained within a thermostatically controlled enclosure continually adjustable up to 150 degrees Centigrade. Also included is an electronic strip chart recorder. The Series 9475 C is similar but with special internal arrangement, heavier insulation and special heating system to operate up to 225 degrees C. The Series 9845 is a continuous automatic recording plant stream analyzer. Podbielniak, Inc.

Circle E25 on the Card.

Variable Speed V-Belt Drives—A 44-page booklet carrying handy multicolor tables for quick and easy selection of variable speed "Texrope" drives has been released.

In addition to providing selection tables for A, B, C and D section variable speed drives, the booklet includes information on design features, drive principles, horsepower rating tables for A, B, C, D, and E section belts, a speed range table showing the variation in rpm when using two "Vari-Pitch" sheaves in combination, and accessory equipment for the "Vari-Pitch" drive. Allis-Chalmers Manufacturing Company. **Circle E26 on the Card.**



Pneumatic Timer—A pneumatic timer for use in automatic control circuits such as machine tool sequencing, process industry operations, cranes, and conveyor lines, has been developed.

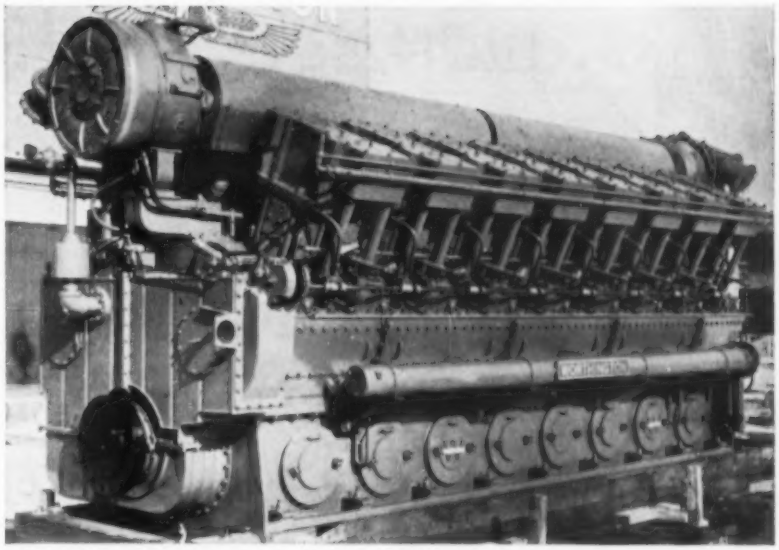
Designed for heavy duty applications, it has a time delay of 1/5 of a second to 180 seconds, with an accuracy of plus or minus 10 per cent of the setting. A G-E Strongbox coil on the magnet structure sharply reduces coil failure by excluding dirt and moisture, and protects the windings from slipping screwdrivers and other mechanical damage. General Electric Company. **Circle E27 on the Card.**

Propylene Diamine—A new technical bulletin presents information on the uses of propylene diamine and its physical and physiological properties, specifications, shipping data, and constant-boiling mixtures.

Propylene diamine is a strong organic base used in the synthesis of chelating and sequestering agents for fuel oil and high octane gasoline. It is a useful ingredient of rust inhibitor compositions. Glyoxalidine derivatives prepared from propylene diamine are effective corrosion inhibitors and detergents for lubricating oils.

Propylene diamine is a useful solvent for reclaiming gelled baking enamels and styrenated alkyds. Carbine and Carbon Chemicals Company.

Circle E28 on the Card.



Dry Dye Eduction Probe—To make the dyeing of gasoline cleaner, faster and simpler, a new dry dye eduction probe plus a new method of measuring airflow through the probe has been developed.

This new dry dye eduction probe, although simple in design, has many advantages over conventional dye probes, which are little more than pipe sections. One of the main advantages is that many field tests under a wide range of conditions have shown it to be clog proof. This probe makes it possible for dye from the shipping drum to be introduced directly into the finished gasoline, eliminating the step of pre-dissolving, necessary with some systems.

The probe consists of an aluminum tube within a tube. The inner tube, similar to the tube for a tank type vacuum cleaner, sucks the dye from the container into the gasoline stream. The outer tube, the part which makes it different from other eduction probes, supplies a downdraft of air. This downdraft is controlled by two adjustable ports at the head end which insure a continuously fluidized flow of dry dye uninterrupted by clogging. E. I. Du Pont de Nemours & Company.

Circle E29 on the Card.

New Bulletin on Steam Pumps—"How to Install and Take Care of Steam Pumps" is the title of this new 23-page bulletin.

A step-by-step series of 88 illustrations and appropriate captions presents the reader with information on increased service life of all types of steam pumps.

Specifically designed to aid operators and maintenance men in adding years of reliable service to steam pumps, the new literature offers 28 tips on proper installation, and 54 tips on field-proven care techniques. Worthington Corporation.

Circle E30 on the Card.

New Diesel Engines—A high output, four-cycle engine, designed specifically for turbocharging, and for brake mean effective pressures of 200 p.s.i. and above has been developed. Actually it can be three engines in one; for operation on Diesel oil, oil and gas, or all gas.

Two types of high output engines were developed to complement various applications in municipal and industrial power plants, water works, sewage plants, for emergency service, semi-portable and portable service, and for topping service in steam power plants.

One type is a medium speed 900 to 1000 RPM unit that employs a hung crankshaft; while the other is a low speed, 450 RPM engine with the crankshaft bedded in the base. The medium speed unit is presently an in-line type with ratings from 400 to 1400 horsepower, while the low speed engine is built both in-line and in Vee engines with a range from 1500 to 5000 horsepower. The engines are used mainly for driving electric generators, blowers, pumps, compressors and other machinery. Worthington Corporation.

Circle E31 on the Card.

Easy to Clean Solenoid Valve—Precision Solenoid Valves feature a removable operating assembly to facilitate inspection and cleaning or complete replacement of operating parts without disturbing the electrical connection (if flexible conduit is used), and while the valve body remains in the pipe line.

This feature of Magnatrol solenoid valves is of prime importance in chemical feed lines, where the fluid handled has a tendency to build up petrous deposits. Quick access to the interior of the valve enables the operator to clean and reassemble the valve with a minimum of shut-down time.

Disassembly of valve may be completed in three simple steps. After the bonnet ring has been decoupled, the hermetically sealed solenoid cup with attached flexible power feed line is removed from the valve body. Last, the complete interior valve mechanism is taken out as a unit. The valve body remains in the line, ready for inspection or cleaning. Magnetrol Valve Corporation.

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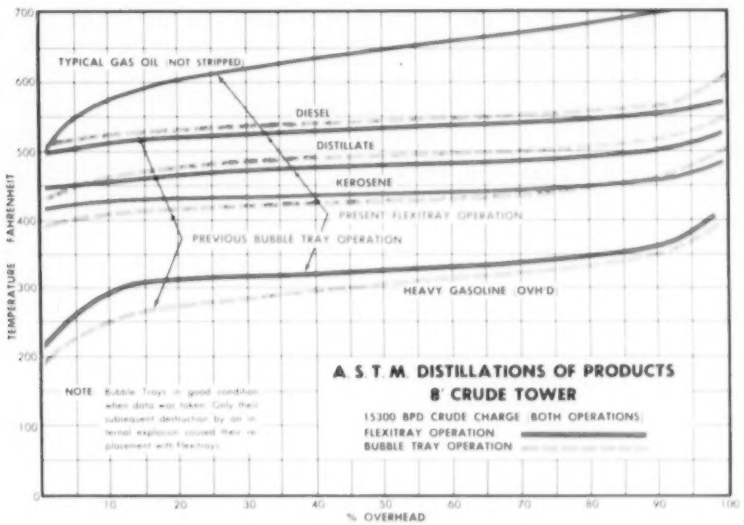
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FLEXITRAY OPERATION
BUBBLE TRAY OPERATION
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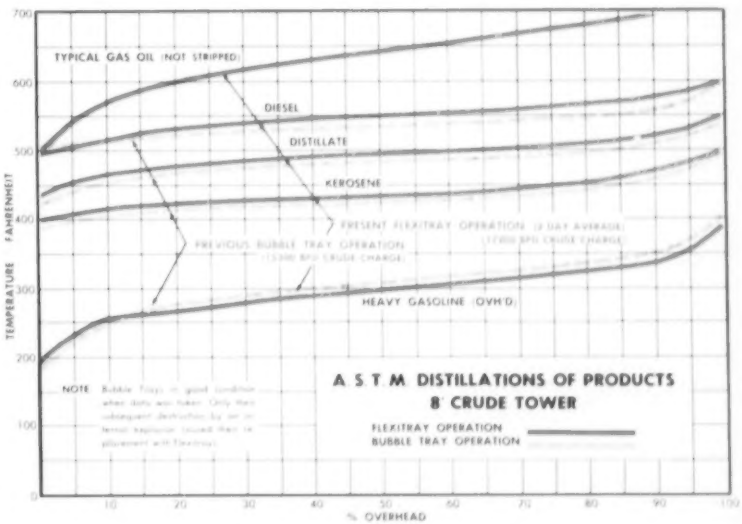

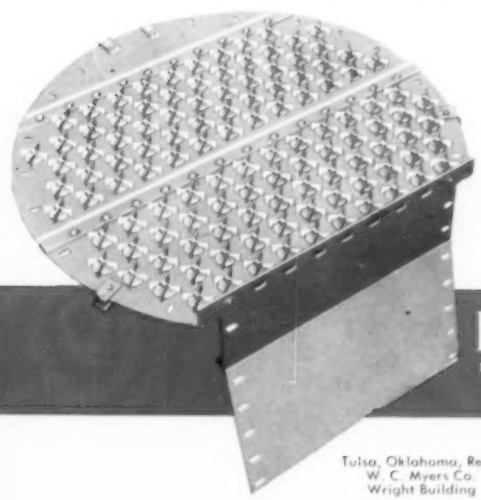

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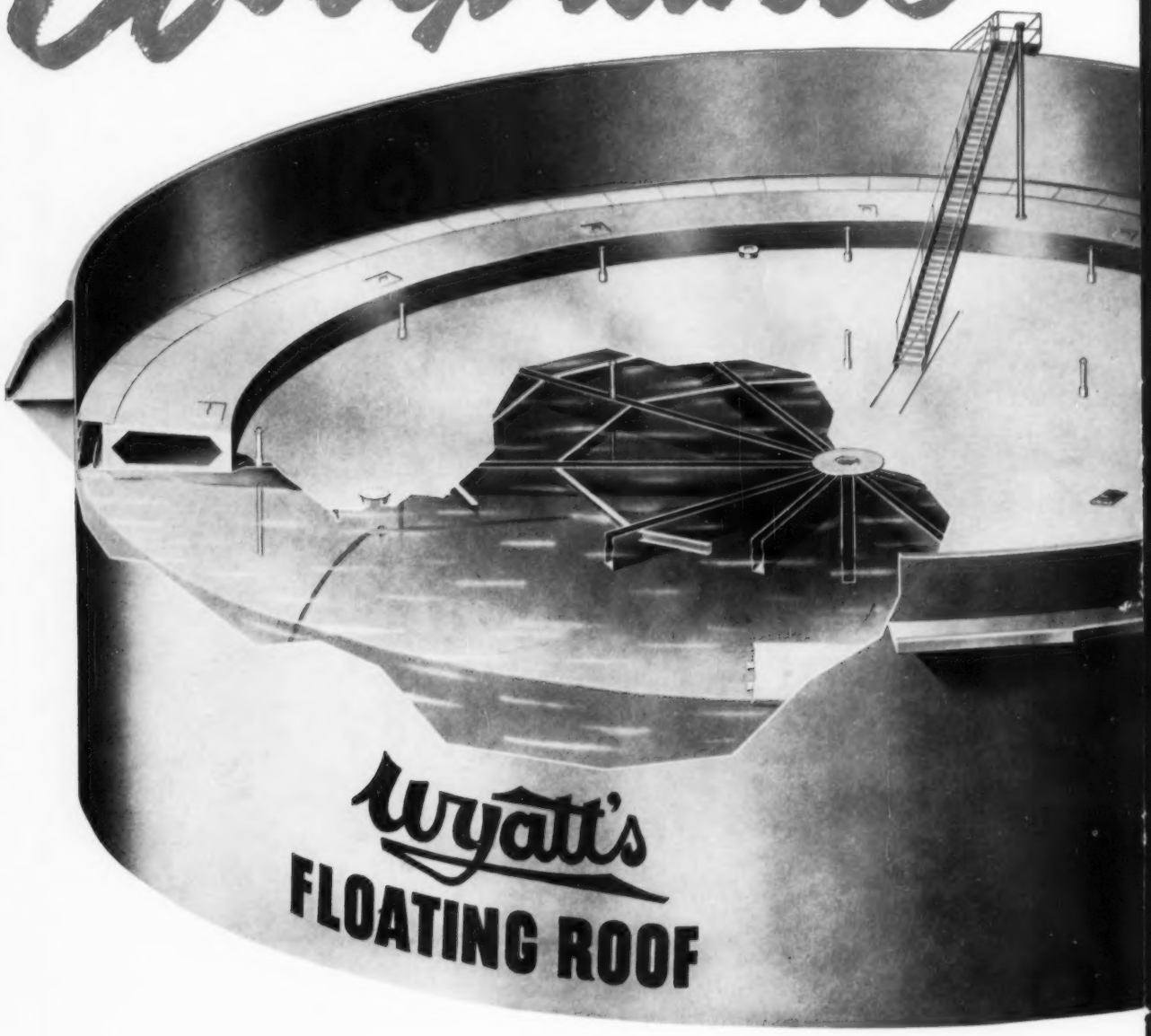

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